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ISSUED QUARTERLY

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1952 - 1953

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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

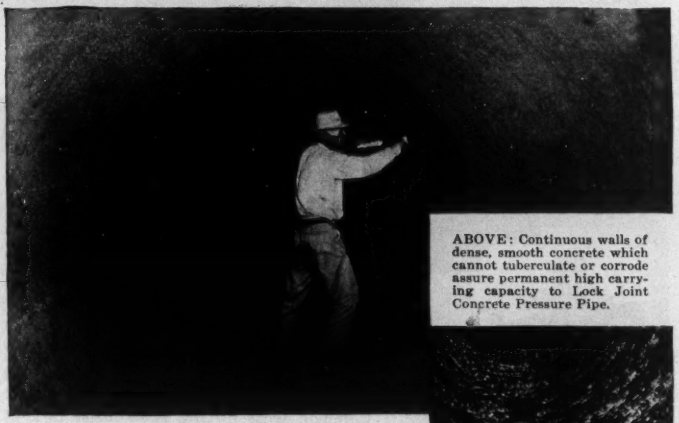
A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

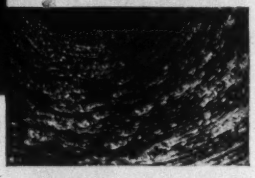
Initiation Fees		*Annual Dues*	
Members	$ 5.00	Members	$ 6.00
Juniors	1.00	Juniors	3.00
Associates	10.00	Associates	20.00
Corporate Members	10.00	Corporate Members	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

CONCRETE *is the answer to your main problem*



ABOVE: Continuous walls of dense, smooth concrete which cannot tuberculate or corrode assure permanent high carrying capacity to Lock Joint Concrete Pressure Pipe.



ABOVE: The tuberculated condition of this metallic pipe reduces its carrying capacity 50%.

Tuberculated mains—corroded mains—leaky mains—all cost municipalities, taxpayers and industry immense sums every year in added pumping costs, maintenance and repairs. Yet, by the use of Lock Joint Concrete Pressure Pipe, all of this unnecessary expense could be eliminated.

1. LOCK JOINT PRESSURE PIPE does not tuberculate...

RESULT
- **No excessive pumping costs**
- **No periodic cleaning costs**
- **No loss of income from inadequate delivery of water.**

2. LOCK JOINT PRESSURE PIPE does not corrode...

RESULT
- **No cost for major repairs**
- **No cost for periodic patchwork**
- **No loss of revenue while the line is closed for repair.**

Consider these facts when you plan your next water supply or transmission main and specify Lock Joint—the pressure pipe of perpetual economy.

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Lock Joint Pipe Company for over forty years has specialized exclusively in the manufacture of reinforced concrete pipe for water supply and transmission mains as well as for sewers, culverts and subaqueous installations.

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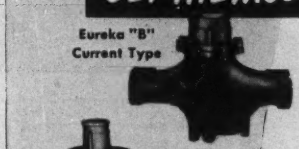
Oscillating Piston

Empire Type 14
Oscillating Piston

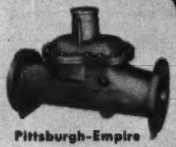
Tropic
Disc Type

It's good business
at any time to

GET THE MOST OUT OF YOUR METERS



Eureka "B"
Current Type

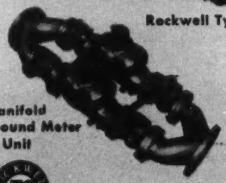


Pittsburgh-Empire
Compound Type

Empire Type 16
Oscillating Piston

Arctic
Disc Type

Rockwell Type 6



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Unit

IT'S ESPECIALLY TRUE NOW!

Common sense dictates good meter care. Especially now, with new water meters in short supply it is imperative that existing meters be kept in good condition.

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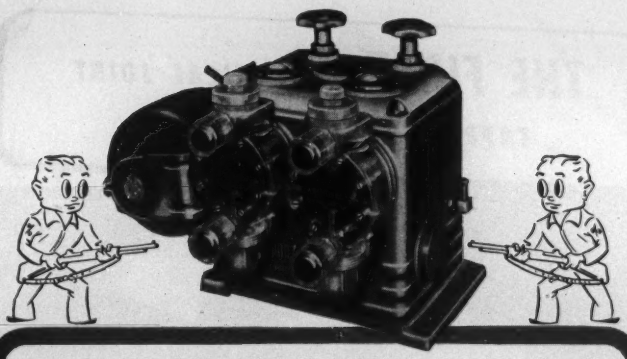

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3. Pumping action is visible to the operator.
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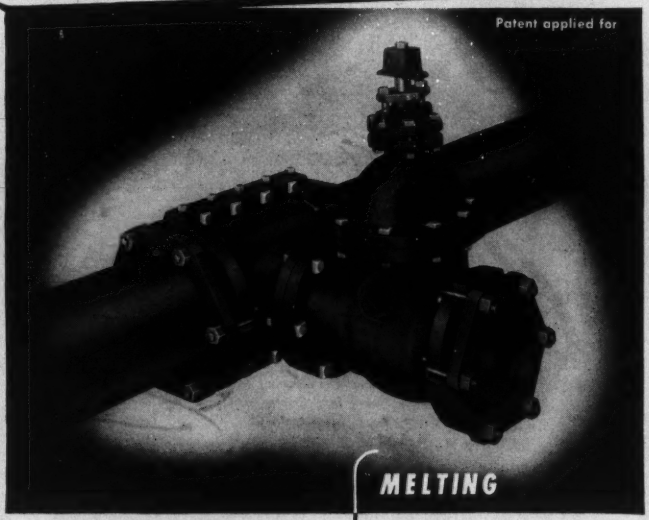

ELIMINATES { MELTING, POURING, CAULKING

A new *all* Mechanical Joint Tapping Sleeve and Valve, installed quickly and easily even by untrained workmen using a ratchet wrench. There are no joints to pour and caulk.
Installation can be made in wet trenches in any kind of weather.
The "Stuffing Box" type joints require no cutting or scarfing of rubber gaskets on job. Assemble Sleeve on main—attach the Valve, the installation is complete and the joints are permanently bottle-tight.

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FIRE HYDRANTS
INSERTING VALVES
TAPPING SLEEVES AND VALVES
WATER SERVICE BRASS GOODS

THE A. P. SMITH MFG. CO.
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TAPPING MACHINES
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PIPE CUTTING MACHINES
CORPORATION TAPPING MACHINES

THE WORM THAT TURNS THE LOCK THAT LIFTS!

A strong, effective lock, insuring safety for the meter and the pedestrian.

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FORD

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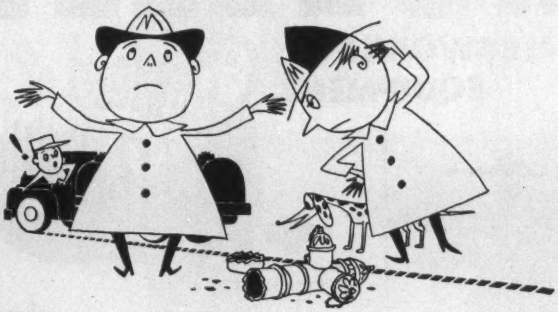
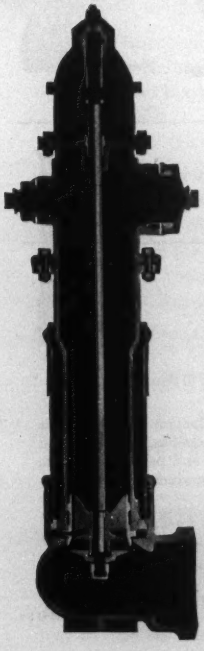
District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh, and Woodward, Alabama

Broken hydrant cannot leak!





The main valve opens against water pressure and closes with it. This is foolproof protection against flooding when hydrants are broken in traffic accidents.

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HYDRANTS

Made by R. D. Wood Company Public Ledger Building, Independence Square, Philadelphia 5, Pa. Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves.

Mathews Modernized Hydrants . . . Tops in Convenience and Dependability Compression-type valve prevents flooding • Head turns 360° • Replaceable head • Nozzle sections easily changed • Nozzle sections raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • Operating thread only part to be lubricated • All working parts contained in barrel • A modern barrel makes an old Mathews good as new • Available with mechanical joint pipe connections

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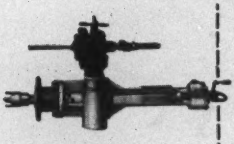

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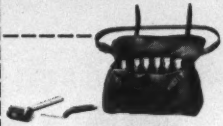

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GATE VALVES

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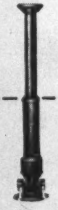


FIRE HYDRANTS

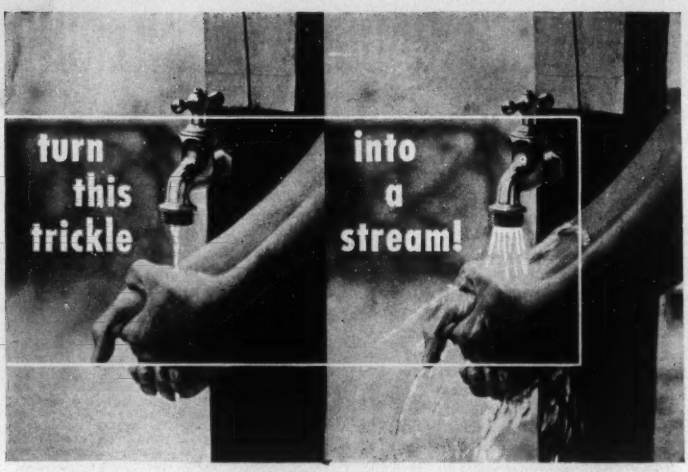
REDUCING & REGULATING VALVES
No. H-9000

MUELLER CO. offers you a complete selection of waterworks distribution equipment, supplies and specialties designed and manufactured to high standards of quality and perfection. Write for catalog information on any of these product lines.

MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS



If loss of pressure is your water problem, the source of trouble may be tuberculation and corrosion in your pipelines. In this case the Centriline process can turn this trickle into a stream . . . and can put smiles back on the faces of the taxpayers of your community.

Centrilining is the application of cement mortar to the walls of pipelines in place, after cleaning. At a fraction of the cost and trouble of replacement, Centrilining extends the life of old pipes *indefinitely*. For complete information on this time proven process, write for your free copy of Centriline's new booklet.

Pipelines 4" to 14" are cement-lined by the Tate Process.

CEMENT-MORTAR LININGS FOR PIPES IN PLACE

2,500,000 FEET **OF EXPERIENCE**

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ADVANCED BADGER ENGINEERING

brings you the DOVETAIL THRUST ROLLER INSERT

Because BADGER METER engineers refuse to "rest on their laurels," they continue to maintain the world's highest standards of water meter performance. This new Badger Dovetail Thrust Roller Insert is typical of the constructive research and precision achievements in progress continually at BADGER.

What does this Badger Dovetail Thrust Roller Insert accomplish? It saves important time and replacement costs... because, with this removable plate set into the chamber wall, the thrust roller (in the disc) rolls against the *insert* only... thus preventing wear directly in the chamber thrust roller *slot* (which would damage the chamber itself). If wear occurs on the *insert*, that is no problem, because it can be replaced easily, at a small fraction of the cost and time required to replace an entire new chamber.

In addition, advanced Badger engineering of this unique insert assures you of accurate metering through unimpaired freedom of disc movement, because:

1 Both halves of chamber remain stronger, since this insert requires only a short slot (about 77% shorter slot milled in chamber wall).

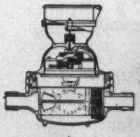
2 Precision design and machining permit insert to be held accurately and securely in place between the two halves of the chamber.

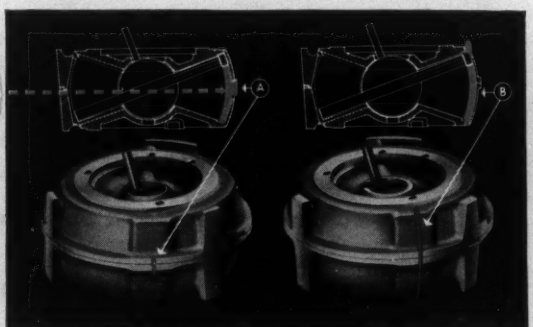
3 The precision dovetail design prevents insert from shifting or moving.

4 The increased radius of the insert along the area nearest the disc, assures ample clearance always between disc and insert, even in the extreme allowable vertical shift.

Only in BADGER METERS will you find this advanced type of engineering and precision production which has convinced waterworks men in over 5000 communities that "BADGERS are the best buy in meters."

...another "BADGER-*First*"





A New style: 77% shorter slot... adds strength to chamber-halves; prevents distortion.

B Old style: This full length slot weakened the chamber-halves... made them subject to distortion.

ASK ABOUT OTHER REASONS WHY YOU'LL DO BETTER WITH BADGERS

BADGER METER MFG. CO.; Milwaukee 10, Wis.

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BADGER *Water* METERS

"MEASURING THE WATER OF THE WORLD"

First FOR ACCURACY • LOW-COST MAINTENANCE • DURABILITY • SENSITIVITY

VOLUMETRIC AND GRAVIMETRIC FEEDERS FOR DRY MATERIALS AND THE FEEDING OF LIQUIDS BY GRAVITY

For feeding dry materials by volume
Universal Feeders,
Disc Feeders,
Rotolock Feeders,
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For complete information and Bulletins, address Omega Machine Company (Division of Builders Iron Foundry), 366 Harris Ave., Providence 1, R. I.

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Omega Equipment is serving in the following installations: Bangor, Me.; Brewer, Me.; Bridgeport, Conn.; Concord, N. H.; Lawrence, Mass.; Leominster, Mass.; and many others.

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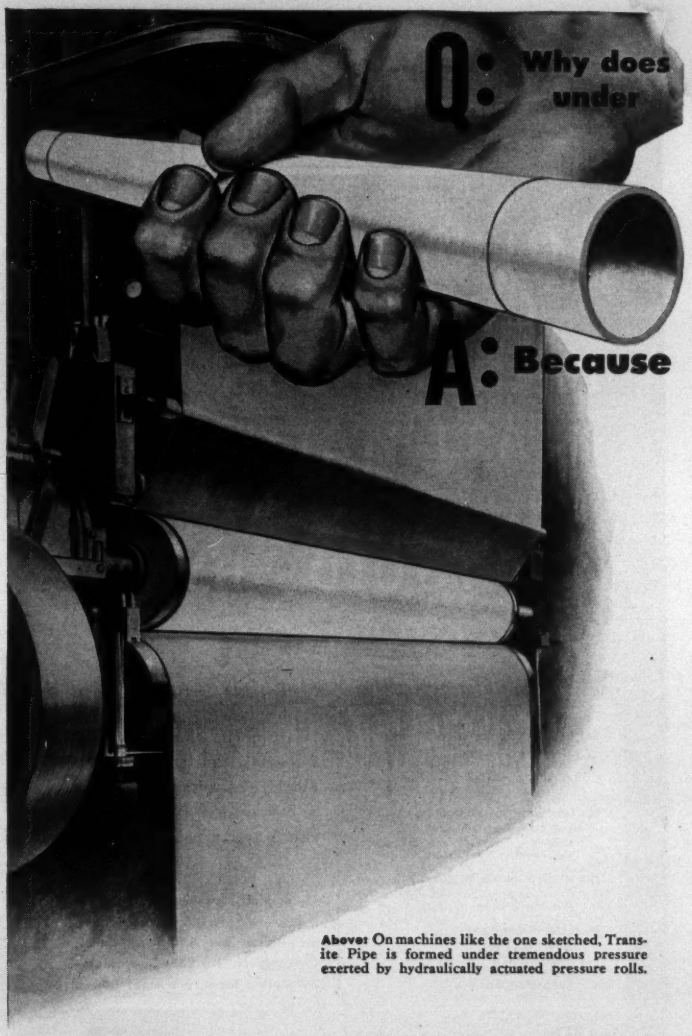
The Last Word in Feeders

OMEGA



Above: On machines like the one sketched, Transite Pipe is formed under tremendous pressure exerted by hydraulically actuated pressure rolls.

Johns-Manville TRANSITE

TRANSITE PIPE last longer these Texas city streets?

In this fast-growing Texas city, the first Transite mains were installed in 1939 to replace previously used pipe which had a service life of approximately seven years. So successful was this original installation under busy streets that today, virtually the entire supply and distribution system consists of Transite mains.

it's formed under tremendous pressure for lasting strength

Yes, it's the all-important quality of *lasting strength* that enables Transite* Pressure Pipe to stand up under conditions highly adverse to ordinary pipe—as typified by the Texas city installation above.

One of the reasons why Transite Pipe has this exceptional ability is the process used in its manufacture.

On specially designed pipe-forming machines, the materials that go into its making—asbestos, cement and silica—are consolidated under heavy pressure into a tough, dense homogeneous pipe wall structure. And reinforcing this structure—distributed uniformly throughout each length of pipe—are countless indestructible fibers of asbestos with a tensile strength comparable to that of steel.

No wonder this modern asbestos-cement pipe stays strong through the years!

And no wonder thousands of American cities and towns have found it the answer to today's need for a pipe that assures the greatest possible return on waterline investments. For in addition to those economies resulting from lasting strength, Transite Pipe also provides other important savings. Its light weight and easy handling reduce installation costs. Its tight, flexible Simplex Couplings cut down on costly leakage losses. Its smooth interior assures a high coefficient of flow (C-140) and, because Transite cannot tuberculate, helps keep pumping costs permanently low through the years.

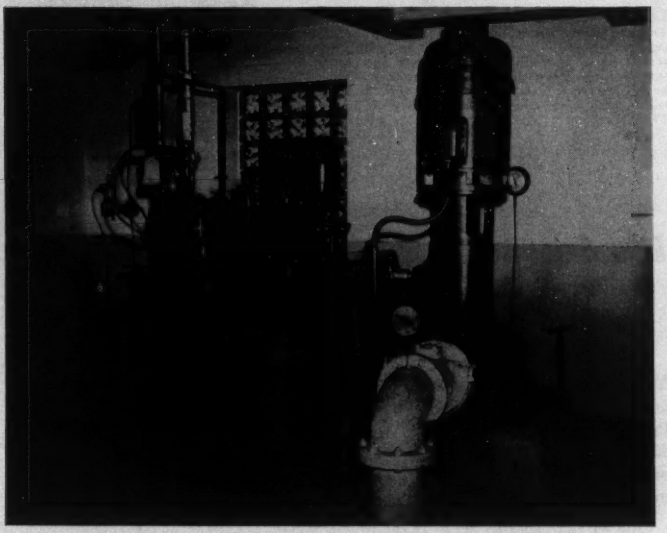
May we send you all the facts? Brochure TR-11A will bring them to you and is free for the asking. Address Johns-Manville, Box 60, New York 16, N. Y.

JM

*Transite is a registered Johns-Manville trade mark.

asbestos-cement PRESSURE PIPE

FAIRBANKS-MORSE SERVES HISTORICAL CONCORD



3 Stage Fairbanks, Morse-Pomona

The Fairbanks, Morse Fig. 6977, water lubricated, deep well turbine pump, pictured above has been supplying water to the town of Concord faithfully since its installation in 1949.

Set in a 24" gravel packed well, 75 feet deep and using a combination drive—electric motor, gasoline engine and right angle gear, the pump normally operates at 700 GPM at 150'TDH but can, and has, supplied Concord's entire demand of 900,000 GPD.

A trained Fairbanks, Morse Engineer is on hand to help solve YOUR pumping problems.

Write or telephone to:

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New England Water Works Association
ORGANIZED 1882

VOL. LXVI SEPTEMBER, 1952 No. 3

This Association, as a body, is not responsible for the statements or opinions of any of its members

RECENT CONSTRUCTION BY THE PORTLAND WATER DISTRICT

BY HERMAN BURGI, JR.*

[*Read September 12, 1951.*]

A brief description of the Portland Water District system might be in order. The source of supply is Sebago Lake, which has an area of 45 sq mi and is in a watershed of 450 miles. Water is delivered through a 54-inch intake and conduit to three transmission lines, which bring water to Westbrook, 13 miles away. From here various mains take water to the distribution systems of Portland, South Portland and surrounding towns (see Figure 1).

Water pressure is by gravity from Sebago Lake, which has an average elevation of 263 ft above mean sea level. The greater part of our water service is required at the in-between elevations of 20 ft to 100 ft, although the District has quite a number of locations above the 100-foot elevation and up to 160 ft. We do not feed from this gravity system elevations greater than 180 ft.

The District, in using a gravity system, has to be very careful as to friction loss in its pipes and, therefore, in general, puts in larger-sized mains, to allow for deterioration and also to be able to utilize as much of the gravity pressure as possible. The District feeds an area of approximately 20 miles east and west by 24 miles north and south.

Because of topography within its system, the District has three divisions, which are separate water-works systems with independent sources: one at North Windham, another at Steep Falls, and the third now being constructed at Standish. It is also necessary to boost the Sebago supply at Gorham because of elevation.

*Treasurer and General Manager, Portland Water District, 16 Casco St., Portland, Me.

30-Inch South Portland Feeder

In the fall of 1948, after years of agitation, the United States Engineers let contracts for the dredging of Portland Harbor to 35-foot depth and notified the utilities using the harbor at the Portland-South Portland Bridge to make way for the dredging. The Portland Water District's 16-inch submarine line, feeding South Portland and laid downstream from the South Portland Bridge, was at 31-35-foot depth and thus had to be moved.

This 16-inch line was constructed in 1923 at a cost of $23,000. During the 26 years of its life, it cost $24,959 in repairs and was found to be leaking considerably when disconnected in 1949.

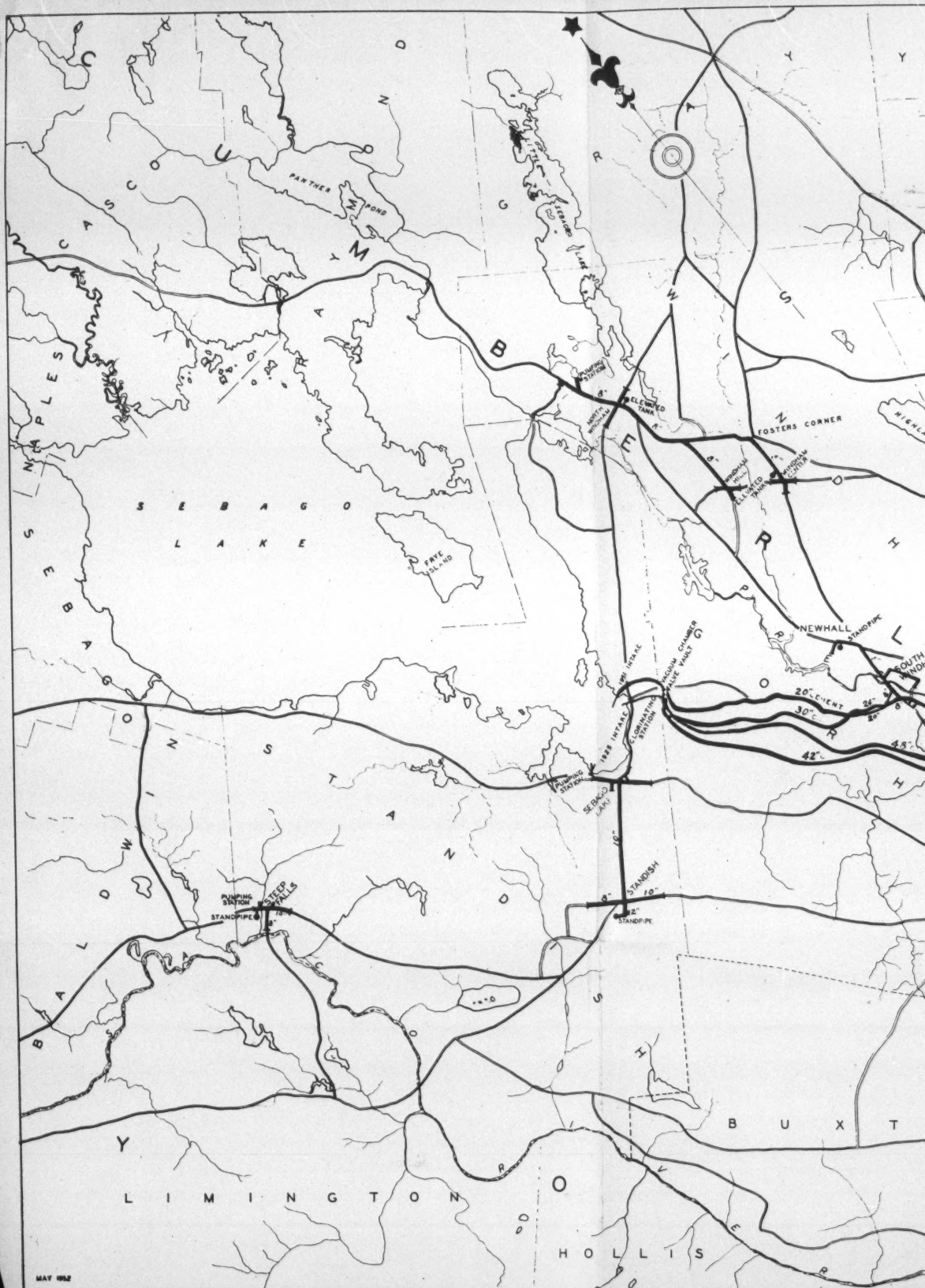
Being forced to get rid of the 16-inch line was quite welcome. because of the maintenance costs and because the city of Portland's pressure was affected by having most of South Portland's water go through the Portland distribution system. We found that when the 16-inch line was shut in the fall of 1949, the city of Portland's pressure went up five pounds.

The dredging was to give a clear 35-foot channel at mean low tide. The United States Engineers' plans call for 40-foot depth some years hence, and that would mean that the Portland Water District would have to lay a new submarine line at 45 ft below low water. The reason for the depth is that fresh-water mains laid in salt water in Portland freeze, unless they have cover. Salt water gets down to 26° F. and a fresh-water line, with tidal salt water flowing over it, is just like a water line in a freezer.

To replace the 16-inch line, ordered removed by the U. S. Engineers, and to get away from submarine main troubles, it was decided to run a 30-inch overland line, having the advantage of:

1. Direct line from the Sebago Lake transmission lines in Westbrook to South Portland and Scarboro.
2. New territory and routing separated from existing pipes.
3. Loop feeding radially into South Portland and radially out to Cape Elizabeth.
4. Possibility of large-capacity standpipe at high-point area in South Portland as local storage for South Portland and Cape Elizabeth.

Connection of this proposed 30-inch line to the existing 30-inch



CUMBERLAND
CASCO
RAYMOND
NAPLES
SEBAGO LAKE
FRYE ISLAND
PANTHER POND
LITTLE SEBAGO LAKE
GRAY
WINDHAM
PRIDE
GORHAM
STANDISH
BALDWIN
SACO RIVER
BUXTON
LIMINGTON
HOLLIS
PUMPING STATION
ELEVATED TANK
NORTH WINDHAM
FOSTERS CORNER
WINDHAM HILL
ELEVATED TANK
WINDHAM CENTER
NEWHALL
STANDPIPE
SOUTH WINDHAM
1951 INTAKE
VACUUM CHAMBER
VALVE VAULT
1925 INTAKE
CLORINATING STATION
PUMPING STATION
SEBAGO LAKE
STANDISH
STANDPIPE
PUMPING STATION
STEEP FALLS
STANDPIPE
20" CEMENT
30"
42"
48"
MAY 1952

F

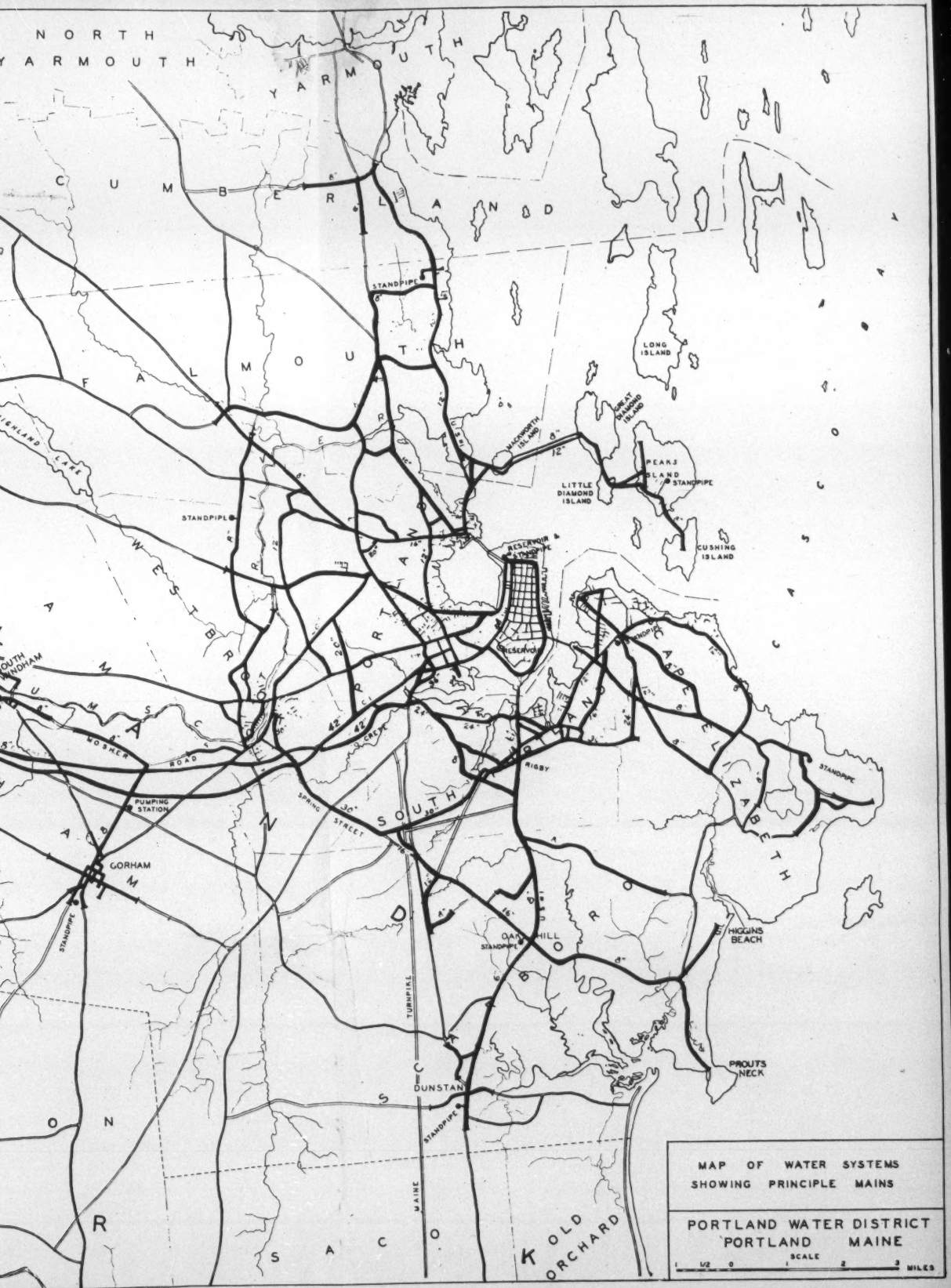

NORTH YARMOUTH
YARMOUTH
CUMBERLAND
FALMOUTH
WESTBROOK
PORTLAND
SOUTH PORTLAND
CAPE ELIZABETH
SCARBORO
SACO
OLD ORCHARD
CASCO BAY
LONG ISLAND
GREAT DIAMOND ISLAND
MACKWORTH ISLAND
PEAKS ISLAND
LITTLE DIAMOND ISLAND
CUSHING ISLAND
RESERVOIR & STANDPIPE
RESERVOIR
STANDPIPE
PUMPING STATION
GORHAM
MOSHER ROAD
SPRING STREET
RIGBY
OAK HILL
HIGGINS BEACH
PROUTS NECK
DUNSTAN
TURNPIKE
MAINE
MAP OF WATER SYSTEMS SHOWING PRINCIPLE MAINS
PORTLAND WATER DISTRICT
PORTLAND MAINE
SCALE
MILES

FIG. 1.

tie-line between the 42-inch and 48-inch transmission lines in Westbrook allows for feeding South Portland from either or both transmission lines.

The 30-inch line was laid as much as possible in private rights-of-way, for safety and protection to the line and its location, and as being cheaper in not having paving costs. We used 30-inch, Class 150, prestressed cylinder Lock-Joint pipe, with 8-inch outlets installed every 1,000 ft and 2-inch outlets every 500 ft. The valves were attached, even if blanked off.

In the construction of the 16-inch and 30-inch lines, it was necessary to cross the Maine Turnpike in two locations. This was accomplished by driving a 54-inch concrete shield for the 30-inch line, about 2,000 ft east of Spring Street, and at this location we ran into hard, dry clay. The 42-inch shield for the 16-inch line at Spring Street was driven through sand and, in spite of the dry weather in 1949, we ran into water about 18 in. below normal surface. Well points, enclosing the 42-inch shield location, allowed for the driving of the shield from the parkway in the center of the Turnpike to each side. The Turnpike is 300 ft wide.

The 1949 construction carried the 30-inch line to the Portland Terminal Company's tracks at Route 1, which crossing is known as Rigby, where we connected into an existing 12-inch line, feeding east and west in South Portland. Work was started on the 30-inch line at Rigby and carried across the railroad tracks and U. S. Route 1 in May, 1950, so as to get ahead of the summer traffic.

At Rigby we went 14 ft under the Boston & Maine tracks with a 54-inch shield. Both here and at the Turnpike there was no interruption of traffic during the tunneling operations.

Route 1 in South Portland was crossed in two "bites": first, the north side of the street for one-half of the paving, and then backfilling and repaving that half prior to opening the second half. Again well points were used to create dry-ditch pipe-laying. Later, when we got to the Portland Terminal Company's Turner's Island tracks, we found wet sand-digging and once more well points came to the rescue.

The 30-inch line from Highland Avenue to Sawyer Street was a tough job, because of a ledge plateau at elevation 150 ft, which required the excavation of 2,000 cu yd of rock, and on the Sawyer Street end we had to come down at a 20° angle in solid ledge, to get down to about 35-foot elevation.

Terminating at Eastman Road and Sawyer Street with the 30-inch line will allow for the running of future lines into Cape Elizabeth radially from this location, a large water source being thus provided at a center of the area.

24-Inch Cape Elizabeth and South Portland Loop

To make good use of this 30-inch pipe, one 24-inch radial feed was constructed in 1950 along the South Portland-Cape Elizabeth town line, going east into South Portland at Cottage Road and Sawyer Street.

For safety, a large main should not be laid in a street where a large pipe already exists. This route was chosen because of an existing 12-inch line in Broadway and a 16-inch line in Nutter Street and Highland Avenue. Sawyer Street would have been the next logical street going from the Cash Corner area toward the Knightville area, but Sawyer Street is all ledge, very crooked, and narrow. From an economic standpoint, the cost was much less to buy this chosen right-of-way, which was practically all sand-digging, although wet, and to arrange to feed both towards South Portland and out into Cape Elizabeth. This might be called an "Outer Loop" around South Portland.

In 1950, we connected an 8-inch and 12-inch pipe on Ocean Road towards Cape Elizabeth from this 24-inch line. The Fire Chief tells me that he has noticed an increase in his hydrant capacity in the Pond Cove area, and well he should, since in 1949 we had a 20-lb pressure drop from Highland Avenue to Spurwink Avenue on the summer load through the 8-inch line.

Where the 24-inch line ends at Sawyer Street and Cottage Road, we feed into a 12-inch line in Cottage Road going west towards Knightville, into a 12-inch line going north towards Ferry Village, and into a 12-inch line going east along the Cape shore. There are other opportunities for radial feeders towards Cape Elizabeth and South Portland, one of which we constructed by running a 12-inch line along Pitt Street, which later will feed back into the Highland Avenue lines.

1950 Results of 30-Inch South Portland Line

With the loss (by disconnection) of the 16-inch submarine main into South Portland, the Stroudwater connection through Cash

Corner and Pleasantdale did not supply enough water to hold up pressure, and thus all sprinkling had to be stopped in South Portland and Cape Elizabeth on July 28, 1950.

When, on August 20, the 20-inch tie between the 30-inch Lock-Joint pipe and the existing 16-inch line at Evans and Nutter Streets was turned on, that area experienced a 7-lb increase in pressure, and at Knightville Fire Station the pressure went up 5 lb. This illustrated the necessity of carrying the 30-inch pipe into South Portland and to the Cape Elizabeth line, since the tap into the 12-inch pipe at Wythburn at Rigby tracks did not aid Knightville during June, July and August, 1950, until the Evans Street tap was made.

16-Inch Feeder to Oak Hill, Scarboro

The water supply to Prout's Neck and Higgins Beach was fed through an 8-inch line, which now is under the middle of the four-lane concrete U. S. Route 1 in Scarboro from South Portland to Oak Hill, a distance of approximately three miles. There were times during the summers of 1948 and 1949 when there would be hardly any water pressure at Prout's Neck, which is 60 ft above low tide. The 90-foot standpipe at Oak Hill, with the base elevation of 114 ft, at times was less than half full. This condition had to be corrected, and along with the construction of the 30-inch line, a 16-inch tap was made near the Turnpike to go along Spring Street to Oak Hill. This is 16-inch Lock-Joint pipe, Class 150, prestressed. Outlets along this pipe are laid out as follows: 8-inch outlets every 960 ft, so as to allow for hydrant installations. Between two 8-inch outlets there is one 2-inch outlet halfway, as well as two 1-inch outlets between the 2-inch and the 8-inch. This means that it is possible to tap this line every 240 ft. Practically all of this line was laid on a private right-of-way, parallel with the street.

Approximately 3,000 ft of this 16-inch line, which crosses the Maine Turnpike, was laid in 1949. In March of 1950, the Lock-Joint Pipe Co. started shipment of the 14,714 ft of 16-inch pipe. The A. Stanley Mundy Co. began laying the pipe on April 25 and finished June 19, 1950, when the water was turned on.

This connection materially increased the pressure conditions at Dunstan, Higgins Beach and Prout's Neck. At one time during July

of 1949, this standpipe had only 15 ft of water, and during the summer of that year, with controlled sprinkling, the District could maintain it about half full. In 1950, it remained full.

Town of Windham (North Windham Division)

In 1938, the Portland Water District constructed a system in North Windham, fed from driven wells located on the shores of Chaffin Pond. Due to elevation, it was necessary to supply this community by pumping. This area is above Sebago Lake levels.

In 1948, the town of Windham requested an extension to Foster's Corner and Windham Center. After negotiations, on February 4, 1950, the town of Windham authorized the Selectmen to sign a contract with the Portland Water District for extension of the North Windham system along U. S. Route 302 to Foster's Corner and then along Route 202 to Windham Center. Contracts were let to lay the 14,046 ft of 8-inch pipe and for building the elevated-tank foundation and valve-control house. A 200,000-gal elevated tank was erected by the Chicago Bridge and Iron Co. The District laid and connected the services. Water service was made available December 14, 1950. The contract with the town of Windham for water service was on the basis of a guaranteed gross revenue of 8% of the construction cost. The actual cost of the construction was $147,105.

Town of Standish

When chartered in 1907, the Portland Water District was given a franchise to supply water to the cities of Portland, Westbrook and South Portland, and the towns of Standish, Windham, Cape Elizabeth and Scarboro. Until the Steep Falls construction in 1950, the District did not supply water service in Standish.

Part of Sebago Lake is in the town of Standish. The District owns land along the shore on each side of its intake, which land was purchased for the purpose of protecting the purity of the water.

The District pays taxes on this land, and the tax is about the same as the town would receive from individuals, except that the townspeople do not get the trade in the village from a possible increased population. The inhabitants had a good local source of water, but it was not available at their houses. They felt that the Portland

Water District should exercise its franchise rights to serve the territory.

Standish has always wanted a water system, and the forest fires in 1947 and the dry weather in 1947, 1948 and 1949 pressed the demand for service. After protracted negotiations, a contract was signed and ratified by the town at a special town meeting in February, 1950, for a $337,000 water system, with the inhabitants paying 8% gross revenue per year.

This required two separate systems: one system taking water from Sebago Lake and supplying Standish Corner and Sebago Lake Corner, and the other system at Steep Falls, about seven miles away from Standish Corner, taking water from a well system.

The Steep Falls system was built in 1950 with the drilling of nine 2½-inch wells and the construction of a pumping station with both electric and gasoline pumps. A 350,000-gal standpipe, 60 ft high, was set on a rock ledge, 60 ft in elevation above the town's main street. A 10-inch transmission line was laid along Route 114, with 8-inch pipe on the side extensions.

Service was started on December 23, 1950, and by January 15, 1951, there were 60 customers served with water and the town had hydrants for fire protection.

Mosher Road

On August 16, 1950, the Portland Water District received notice from the State Highway Commission of the rebuilding of Mosher Road from Mosher's Corner to South Windham, requiring cuts and fills which would damage the 24-inch cement main, constructed by the Portland Water Co. in 1876. This transmission line was tapped to give service to customers along the route.

The District applied to the Public Utilities Commission for permission to cease serving customers on this line along Mosher Road. After a hearing, in which the attorney for the town agreed that the District should apply for higher rates to cover the added cost, the Public Utilities Commission ordered the District to install new pipe and continue service.

This replacement required 8,400 ft of 8-inch pipe, costing $41,199, to serve about 15 customers and two hydrants. This job

was completed about November 15 by Frank Rossi, the highway contractor, who excavated and backfilled while the Portland Water District laid the pipe. Thus the pipe-laying and the highway construction went along smoothly together.

A reason for bringing up this Mosher Road construction is to illustrate a point in utility operation, whereby once a utility has undertaken to give service it is rather hard to discontinue that service. The District has this problem by reason of the fact that it has three transmission lines that are each about 13 miles long, and we always have demands for service from these transmission lines. We still have in service 19,503 ft of 20-inch line built back in 1868, on which there are 59 customers. When it becomes necessary to replace this main, the District will be faced with a cost in excess of $100,000 in order to continue this service. How that will be done I am not prepared to state at this time.

The following costs of the Lock-Joint pipe installed in 1948-1950 may be of interest:

39,486	ft	of	30″	$21.26	per foot
8,941	"	"	24″	14.60	" "
2,713	"	"	20″	15.12	" "
18,039	"	"	16″	10.56	" "
5,472	"	"	12″	5.95	" "

1951

Presently the Portland Water District is finishing the construction of the water-works system in Standish, expecting the major part of the construction to be finished this year.

Also, the District is now engaged in the construction of a 60-inch intake and 54-inch conduit to bypass its present intake. It is expected that the intake will be finished in 1952.

BACTERIOLOGY IN THE TREATMENT AND LABORATORY CONTROL OF PUBLIC WATER SUPPLIES

BY JOHN J. COLLINS, JR.*

[*Read at Chemists' Round Table, Jan. 17, 1952.*]

In any discussion relating to the control of the bacteria content of a water supply one must consider the source of bacteria in water. The rain and snow falling on a watershed collect bacteria from the dust in the air and mix these organisms with those already present in the top soil, due to the excreta of humans and animals and also due to decaying animal and vegetative material. The runoff from the watershed carries these bacteria into the various streams, brooks and reservoirs and it is here that our many problems begin. Treatment plants receiving ground water to be purified usually find a much lower concentration of bacteria, due to the filtering action provided by the flow of water through the earth. However, in the case of subsurface rock formations little of this natural filtration takes place and, under these conditions, the water may contain almost as many bacteria as are to be found in surface supplies.

It is impossible, of course, to keep a watershed entirely free of animal waste products, because of the presence of animals on the watershed and on the many farms usually adjacent to the area. It is possible to keep a watershed almost entirely free of human waste products by legislation forbidding trespassing of any kind and by constant and vigorous patrolling of the area to enforce this legislation.

However, despite the many elaborate precautions that are exercised, bacteria are certain to enter the raw water supply. It then becomes the express duty of those responsible for laboratory control to detect these organisms and specify the proper treatment for their removal without impairing the esthetic qualities of the water. The most important examination that sanitarians must make is that for the presence of organisms of the coliform group, a group of parasitic, non-pathogenic bacteria present in the intestines of all warm-blooded

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animals. In addition to members of the coliform group, which includes all aerobic and facultative Gram-negative non-spore-forming bacilli which ferment lactose with gas production, there are two other groups present in the intestinal tract; the anaerobic lactose-fermenting spore-formers and the fecal streptococci. Since the spores of the anaerobic lactose-fermenting spore-formers and the fecal streptococci are quite viable, they can survive in water for a longer time than the coliform. Because of the relatively short life of the coliform organisms, as compared to the other groups of intestinal bacteria, we have a very good indicator of recent fecal contamination of the water supply in the test for the coliform group.

It is quite apparent, therefore, that a confirmed test for coliform organisms serves warning that the supply has been polluted by fecal material quite recently and that the possibility of the presence of pathogenic bacteria exists. Because the coliform group and the pathogens are not generally a part of the bacterial flora of natural water, they find it very difficult to thrive. However, whenever polluted water enters the human body, it carries its pathogens into the mouth and then to the gastro-intestinal tract, provided these pathogens can survive the lethal effects of the mucus of the mouth and gastric secretions of the stomach. If they do survive, they produce the diseases known as water-borne diseases: typhoid fever, paratyphoid fever and cholera. Epidemics of a disease of the liver known as hepatitis have been attributed to the use of polluted water. Other diseases such as amoebic dysentery can be caused by organisms larger than bacteria—the parasitic protozoa.

The test for the presence of coliform organisms in water is rather easy. A lactose-peptone-beef medium is inoculated with the water to be tested and incubated at 37° C. for 48 hours. If gas is formed in the inverted vial any time within this period, it constitutes a presumptive test, but not a confirmed test, because a few other organisms, not necessarily of sanitary significance, may also produce the same reaction. The most common bacteria, other than the coliform group, which produce gas are the spore-formers, both anaerobic and aerobic. In heavily polluted waters these organisms are far in the minority, as compared with the coliform group. In waters having undergone chemical treatment and filtration, lactose may be fermented with the

formation of gas by spore-formers, due to their somewhat greater resistance to treatment. Sometimes a synergism may result in the formation of gas from lactose. This happens when one organism splits lactose into glucose and a second organism, unable to ferment lactose, ferments glucose with the production of gas. It may also be possible to have coliform organisms in water together with spore-formers and yet not obtain a confirmed test for coliform, because during the incubation period overgrowths of spore-formers may destroy the coliform. Whenever a presumptive test is observed, a small amount of the culture is planted in a confirmatory medium such as Brilliant Green Bile Medium, Eosin Methylene Blue Agar, or Endo Agar. Gas production, colony appearance, presence of metallic sheen, etc., are observed and the test is recorded as confirmed or not confirmed. Many attempts have been made to use the lactose broth containing an inhibiting agent to confirm the presence of coliform, by using only this medium for both the presumptive and confirmed tests. There is not much doubt as to the ability of these inhibitors to give a high percentage of true presumptives, but it is equally true that weaker strains of coliform may also be inhibited—strains that ordinarily could be nourished in the plain lactose broth. For this reason "Standard Methods for the Examination of Water and Sewage" calls for incubation in the absence of inhibitors in the presumptive tests. In a study of the coliform bacteria from chlorinated waters Levine (1) compared Lactose Broth and Lauryl Tryptose Broth. The latter medium gave fewer false positive presumptive tests than did Lactose Broth and suppressed the spore-forming aerogenic bacteria. However, organisms showing a delayed fermentation of lactose were not eliminated by Lauryl Tryptose Broth. Further studies by other investigators showed that the substitution of Lauryl Tryptose Broth for Lactose Broth would result in a reduction in the number of primary gas positives to be confirmed and an increase in the number of positive coliforms. The Ninth Edition of "Standard Methods for the Examination of Water and Sewage" permits the substitution of Lauryl Tryptose Broth for the Lactose Broth in testing for the coliform group in the examination of all waters except final filtered, treated and filter-treated waters. Standard Methods states that "it may be substituted for lactose broth also in the examination of final filtered, treated and filter-treated waters pro-

vided the laboratory worker has amply demonstrated by correlation of positive completed tests (isolations of coliform organisms) secured through the use of lauryl sulfate tryptose broth with those secured through the use of lactose broth, in the examination of such waters, that the substitution results in no reduction from the density of coliform organisms indicated by the standard procedure using lactose broth"

It is equally important that we do not lose sight of the importance of the plate count as an index of contamination. During the heavy spring thaws and rains dilution may mask the concentration of coliform organisms, while high plate counts may be the only indication that large amounts of contaminating material are entering the raw water supply. While most of this material may be of a harmless nature, it is true that fecal material of human origin may also be washed into the supply. This relation of high plate count and low coliform index happened in the spring of 1908 in Auburn, N. Y., where it was found that the human excreta being washed into the water contained specific typhoid infection and an epidemic in Auburn was the result. In this particular case the total plate count was a more accurate index of danger than was the concentration of coliform.

With modern-day methods for aerating, coagulating, filtering and chlorinating water readily available to water-plant operators, it is a rare occurrence indeed when we hear of water-borne epidemics. Yet, if constant vigilance is not exercised, the water can become polluted after leaving the purification plant. Dual supplies, in which service pipes from city water mains and private supplies are interconnected in violation of good water-works practices, submerged inlets, repairing of breaks in the distribution-system mains, installation of new extensions to the distribution system, etc., are all sources of possible trouble. The water utility should have trained and experienced engineers conduct frequent examinations, to insure the absence of any connection to the city water supply that would permit entry of bacteria or chemicals into the city water mains. When repairing breaks or installing extensions to the distribution system, good sanitary practice dictates a program that does not permit contaminating material to gain access to the supply. Although there is no procedure for the treatment of such mains that has been universally or continuously

satisfactory, the best that the author has seen is the American Water Works reprint, "A Procedure for Disinfecting Water Mains" (2). The September 15, 1948, revision of this document gives a detailed description of how to clean and treat pipe, laying of the pipe, preventing trench water from entering the pipe, packing material, flushing completed pipe-lines, forms of chlorine and means of application, point and rate of application, preventing reverse flows, retention period, sampling, repairing or cutting into existing lines, etc. There are times when we find coliform organisms persisting even after sterilizing newly laid water mains. We have observed that in the majority of cases where a newly laid main has been connected to an existing branch connection containing jute as the packing material, coliform has persisted after repeated chlorinations with dosages as high as 150 ppm of chlorine. When an existing dead-end main is extended, we do not have this problem, the majority of these extensions showing the absence of coliform after one treatment with chlorine. The explanation of this seems to lie in the fact that the jute in the existing branch, in contact with stagnant water for long periods of time, seems to promote an abundant growth of coliform. Since this branch cannot be chlorinated with a large dosage of chlorine without also chlorinating the main in service supplying this branch, chlorination of the newly laid main will destroy only those bacteria that are to be found in that main. However, when water from the branch connection enters this main, coliform most likely will be found. The only success we have had in removing this coliform from branch connections has been by the application of repeated flushings of the branch and the new main.

One of the most important features of laboratory control of a public water supply pertains to the examination of samples collected from consumers' taps in various parts of the distribution system. In order that a public water supply classified as a common carrier under the Interstate Commerce Commission be certified as adhering to and meeting the requirements of the U. S. Public Health Service Standards (3), a minimum number of bacteriological samples must be obtained each month, proportional to the population served. The Standards state that of all the 10-ml portions examined per month, not more than 10% shall show the presence of the coliform group. Since one sample may show a high M.P.N., even though the average

remains at 10% or less, the Standards permit three or more of the five 10-ml portions of one sample to show confirmed tests for the coliform group, provided this does not occur in consecutive samples or in more than one out of every 20 samples examined.

In Providence, bacteriology in the treatment and laboratory control of our public water supply consists of following a routine procedure described as follows: Samples of tap water are obtained daily from not less than eight consumers' taps in various parts of the distribution system, together with a sample for chlorine residual from a point adjacent to the main Aqueduct and samples from Longview and Neutaconkanut distribution reservoirs. Also, samples are obtained daily from the raw water supply and from various stages of the purification process, and monthly from the brooks, streams and reservoirs on the watershed and selected locations in the distribution system. Samples are also collected during the investigation of complaints and following sterilization and flushing of newly laid mains. Some idea of the laboratory control over the quality of the water supply may be had by a comparison of our sampling schedule with that recommended by the Public Health Service Standards. The following table, taken from the Standards, shows the minimum number of bacteriological samples that should be obtained from the distribution system per month for any given population served:

Population served	*Minimum number of samples per month*
2,500 and under	1
10,000	7
25,000	25
100,000	100
300,000	180
400,000	200
1,000,000	300
2,000,000	390
5,000,000	500

The population served by the Providence water supply is approximately 372,000. From the above table, it may be seen that the minimum number of bacteriological samples that should be obtained in the distribution system per month for this population is 195. The actual number of bacteriological samples obtained in the distribution

system for the past year amounted to a total of 3,280 or an average of 273 per month, a figure 40% greater than recommended by the Standards and more than is required for a population of 500,000.

In addition to the many samples collected for bacteriological examination, samples are also obtained from the same sources for physical, chemical, sanitary chemical and mineral analyses. Each delivery of the coagulant, Ferri-Floc, and quicklime is tested to determine its conformance to specifications. Filter washings are regulated by means of tests on the sand expansion and rate of rise of wash water. Coagulation tests are made on one-liter quantities of raw water, treated with various amounts of Ferri-Floc and quicklime, simulating all the operations of the purification processes on a laboratory scale, for the purpose of determining the most economical dosage consistent with good coagulation. All these additional samples and tests are, of course, necessary for the efficient operation of any water-treatment plant, since the information gained by such a procedure enables plant operators to provide proper coagulation and subsequent good filtration, with a consequent high removal of bacteria.

The problems of false presumptive tests for the coliform group, together with the persistence of coliform following installation and disinfection of newly laid mains, remain with us, but the constant tests that are being made by bacteriologists to find some agent that may be added to lactose broth to inhibit the gas formation by organisms other than those of the coliform group and studies on new sterilization chemicals and procedures will some day conquer these problems. The ideal condition of seeding water into only one medium for the purpose of obtaining a confirmed test for coliform must, of course, be permitted by the "Standard Methods for the Examination of Water and Sewage". Any deviation from Standard Methods will, naturally, destroy the unanimity of detection and expression of results now practiced by treatment-plant laboratories.

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2. J.A.W.W.A., Feb., 1948. Reprint 7-D.2, Revised September 15, 1948.
3. U. S. Pub. Health Service. "Public Health Service Drinking Water Standards, 1946." Reprint No. 2697.

SIGNIFICANCE OF RADIOACTIVITY TO WATER-WORKS SUPERINTENDENTS

BY ROLF ELIASSEN*

[*Read January 17, 1952.*]

Much has been written about radioactivity and the water-works profession; much more will be written as new developments are disclosed and their significance to our profession is evaluated. This is a new field of enforced interest to us. Although radioactivity has been known for over five decades, the use of the fissionable properties of certain radioactive substances, such as uranium and plutonium, is less than ten years old. Therefore, we must keep pace with the tremendous strides taken by nuclear science.

The New England Water Works Association has already published two excellent papers by Morris (1) in 1948 and Gorman (2) in 1950. These are packed with valuable information and should be reviewed occasionally, because none of us can keep all of these facts in our memories.

The purpose of this paper is to evaluate some of the recent developments in the atomic energy field and some of the work we have been doing at M.I.T. for the Atomic Energy Commission. From this evaluation we should be able to point to any steps which you as water-works superintendents and operators must take in order to satisfy your municipal authorities, your consumers and yourselves that you are cognizant of the situation and ready to take any necessary precautionary measures.

First let us review some of the basic concepts of radioactivity. So many writers have presented so much confusing material, that we lose sight of how simple radioactivity really is—basically as simple as A-B-C. Natural radioactivity is caused by an unstable atomic nucleus which usually contains one or more extra neutrons, when compared with the stable isotope of the same element. These neutrons have been spoken of as "frustrated neutrons". They cannot escape themselves,

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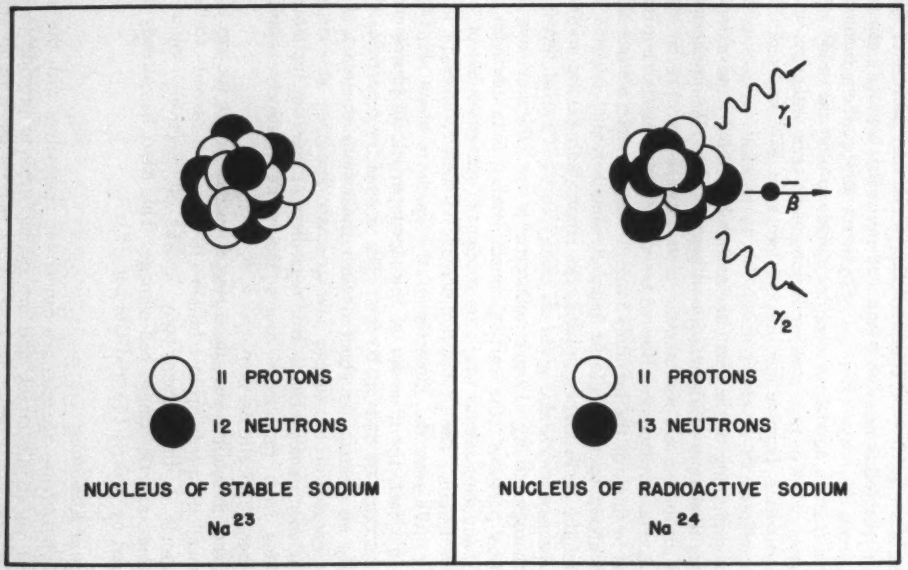
11 PROTONS
12 NEUTRONS
NUCLEUS OF STABLE SODIUM
Na 23
γ1
β
γ2
11 PROTONS
13 NEUTRONS
NUCLEUS OF RADIOACTIVE SODIUM
Na 24

FIG. 1.

but cause the nucleus to emit radiation which may consist of one or more of the following: (a) alpha (α) rays, (b) beta (β) rays, and (c) gamma (γ) rays (Fig. 1). Physicists and mathematicians can perform a great number of complex calculations in the study of the properties of these rays and predictions as to their intensity, energy and occurrence, but for our purposes we need only know the three basic categories: α, β, and γ.

In explaining this subject, the author has found it advantageous at times to compare radioactivity with astronomy. We in the waterworks profession are not nuclear physicists, neither are we astrophysicists or astronomers. But we are not afraid to stretch our imaginations to think of the infinitely large stellar systems; neither should we be afraid to think of the infinitely small atomic systems. We think of the earth and her planet, the moon, both having originated from the sun which also gives off energy in the form of light rays. So with radioactivity. Larger radioactive atoms (the sun) may give off alpha particles (the earth), much smaller beta particles (the moon), and gamma rays which are similar to light waves but of shorter wave length. The principal difference in metrical concept is one of size. Whereas the diameter of the earth is about 40,000,000 (4×10^7) feet, the diameter of the alpha particle is approximately 0.00000000000003 (3×10^{-14}) feet. The mass of the β particle, which is really an electron, is about one-ten thousandth the mass of the alpha particle. These figures are so small that they are virtually meaningless to comprehend. But regardless of size the fundamental radiations from radioactive atoms should be relatively simple to remember—basically as simple as α, β, and γ.

Although small in size, these rays from radioactive sources travel at tremendous speeds up to 1 billion (10^9) feet per second. Collision with atoms in the human body knocks off electrons—known as ionization—and this causes cell damage. This effect has already been discussed by Morris (1) and Gorman (2).

Sources of Radiation

Civil Defense agencies are concerning themselves with the prospects of an atomic attack and are taking steps to provide for the population in the event of disaster. Since the likelihood of an atomic

attack's resulting in a primary water-contamination hazard is extremely remote, defense authorities have listed this as a third-order problem in the target area at the time of the burst of the nuclear weapon (3). If the burst is close enough to a water-treatment plant, there may not be any plant left to be concerned about. In order that the unused bomb materials, either uranium (235) or plutonium (239), neutrons, and radioactive isotopes of the fission products may enter a water source in appreciable quantities, the atomic explosion must take place in a reservoir or on the adjacent watershed. The intentional dropping of the bomb in this fashion is very improbable, since strategic warfare dictates that its destructive force be used against industrial or military centers as primary targets.

If the bomb should be dropped at a greater distance from the water supply than about ten miles from the target area, primary contamination would not be of concern, but secondary contamination by fall-out of particles from radioactive clouds might be significant. If wind direction, rainfall and topography were favorable, it is conceivable that a health hazard might result. The contaminating substances would then be radioactive fission products, such as strontium and rare earth metals, probably as oxides in particulate form. If the water should become contaminated by primary or secondary means, radioactive decay, dilution, and removal by natural agencies would all contribute to the reduction of the contamination in the reservoir. For example, if a bomb were exploded underwater in a large reservoir, natural decay would cause a reduction of neutron-induced radioactivity as shown in Table 1 (4).

TABLE 1.—DECAY OF NEUTRON-INDUCED RADIOACTIVITY IN RESERVOIRS AFTER BOMB EXPLOSION

Time after explosion—hours	*Activity—curies*
0	1,400,000
1	500
24	60
168	0.4

Radioisotopes are being used in increasing quantities for experimental work and medical purposes. Their uses have experienced a sixfold increase since 1947. The disposal of wastes from the labora-

tories of the users of these isotopes is quite closely controlled by the U. S. Atomic Energy Commission and should cause no serious problem in water supplies until their use increases many-fold.

Probably the most significant future source of radioactive water contaminants is the atomic-energy industry itself. Power-producing reactors have already been developed and their use in the future becomes a matter of economic consideration. As these power reactors are put into practical use, possibly as industrial power sources, a serious waste problem may be created unless proper steps are taken. The great quantities of process and cooling waters necessary for such operations, especially if the reactor cooling is by water, will make it necessary for stream-pollution authorities to establish a careful balance between stream utilization for the disposal of radioactive wastes and the normal uses of water for domestic and industrial purposes. Although the atomic-energy industry would like to achieve the goal of discharging no radioactive substances from these installations, this standard would be very difficult to attain because of the cost involved.

Another source of radioactive contamination has been in the newspapers lately. This results from the fall-out of radioactive fission products from the test explosions which have been conducted in the West. Although the amount of radioactivity reaching this part of the country is quite small (5) and will have no effect on the human population, there may be sufficient radioactivity to cause concern on the part of certain industries. The photographic industry, together with its suppliers of paper and chemicals, have been affected in the past (6). This need not concern the operators of municipal water-treatment plants, unless they furnish water to industries allied with the producers of photographic papers or films.

Characteristics of Radioactive Isotopes

Radioactive isotopes which are present in the waste products of fission or are induced by neutron bombardment differ in several basic ways from pollutants present in ordinary domestic and industrial wastes. Many of the individual isotopes are chemically identical with elements encountered daily in food and water. The removal of a particular radioactive isotope would therefore require the removal of much larger quantities of the stable form of elements which have

similar chemical properties and are found in the same group of the periodic table. The permissible concentrations, when expressed in parts per million, further emphasize the unique nature of the removal problem. The recommended permissible level of I^{131}, for example, is 3×10^{-5} microcuries (μc) per ml (7). This is equivalent to 2.4×10^{-10} ppm.

Like any other problem in water treatment, the processes used for removal of impurities depend upon the particle size of the substances present in the raw water. Radioactivity may be present as suspended, colloidal or dissolved matter. Fall-out from radioactive clouds may be in the form of particles of colloidal matter, or even greater in size than colloids. They are probably oxides of the fission products formed after the intense heat of the explosion subsided, and probably mixed with dusts. Fission products and neutron-induced radioactivity may also be dissolved in water in many instances. They will then occur as ions. Some, like strontium (Sr^{90}), yttrium (Y^{90}) and sodium (Na^{24}), will be positively charged ions, or cations. Others will occur as iodide (I^{131}) and phosphate ($P^{32}O_4$) ions, which are negatively charged or anions. For effective removal the nature of occurrence of radioactivity must be known.

Removal of Radioactivity

The most successful measures for the removal of radioisotopes now under study by various AEC organizations and contractors include evaporation, chemical coagulation or carrier precipitation, ion-exchange resins and clays, and biological adsorptive or assimilation processes. Since the wastes of the atomic energy industry present a far-reaching problem, research on removal processes is being conducted at a number of installations of the Atomic Energy Commission and under contract with a number of engineering colleges, such as M.I.T., Harvard, New York University, Johns Hopkins University and the University of California.

At M.I.T., we have been studying the removal of ionic radioactive isotopes by conventional methods of water treatment. As so many of you know from experience with your own treatment plants, good coagulation and settling lies at the heart of the problem. We have found (8) that phosphate containing radioactive phosphorus can be removed (up to 99%) from many typical soft and hard waters by

coagulation with alum or ferric salts and bentonite at a pH of about 6.7.

Conventional water-treatment processes such as you normally use will not remove cations such as strontium. Our research has shown (9) that it will be necessary to have a double coagulation and settling process before filtration. In the first stage, coagulation with lime and tri-sodium phosphate will be required at a pH of about 10.2. Subsequent to this, excess phosphates will have to be removed by coagulation with ferric chloride or sulfate at a pH below 8.0. Total removal of strontium ions in both parts of the process will be about 99%.

Removal by Filters

Filtration experiments on the removal of radioactive phosphorus in alum floc were performed on the M.I.T. pilot-plant filters (Fig. 2). These runs showed decreasing removal with depth, most of the radioactive floc being removed in the top 4 inches, but some penetrating through the filters. The most serious problem which arose was that of filter-sand contamination. Backwashing would not remove all of the radioactivity. This might also occur in your sand filters, particularly if the coagulation processses were not operated at maximum efficiency. Your main defense against such an occurrence is the low probability that your water supply will ever receive radioactive contamination.

These filter runs demonstrate an excellent method for studying floc penetration in rapid sand filters using radioactive tracers (10). Since radioactive elements are detectable in such low concentrations as 10^{-12} ppm, it is possible to follow the removal of the alum floc within filters with great accuracy and to study the adsorption of radioactivity on filter sands. Research on filtration and on methods for the removal of radioactivity from filter sands is being continued, in order to provide answers which we do not have as yet.

Analysis for Radioactivity

Radioactivity can be detected in a number of ways, as suggested by Gorman (2). Accurate counting at the low levels of activity occurring in natural water is difficult to achieve without complex instruments and specialized techniques. Water-works officials need not be concerned about the purchase of expensive instruments (Fig. 3) for

WATER TREATMENT PILOT PLANT
Mass. Institute of Technology
1 Rapid Sand Filters
2 Sedimentation Tank
3 Coagulation Tank
4 Mixing Tank
5 Chemical Feed Pump

FIG. 2.

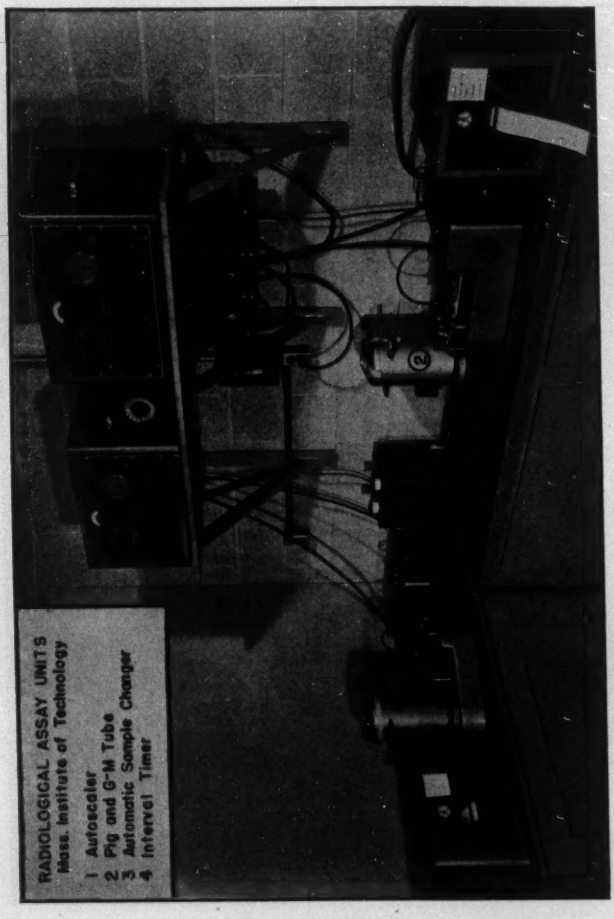
RADIOLOGICAL ASSAY UNITS
Mass. Institute of Technology
1 Autoscaler
2 Pig and G-M Tube
3 Automatic Sample Changer
4 Interval Timer

FIG. 3.

this purpose. It is true that certain simple instruments may be adapted to detect radioactivity on a qualitative basis at emergency tolerance levels, as shown by Hursh (11). But, in general, if you have enough activity for that, you already have too much for normal operations.

For most water-works, the best approach to counting is to have a central laboratory, operated by each State Department of Health, with a technician trained to maintain the counting apparatus and to analyze samples of water. Routine sampling should be undertaken now to establish background data, since most waters will contain some natural radioactivity, although it may be difficult to detect. If the expected radioactivity is known, further routine analyses would disclose changes in the water from sources which could eventually be traced. In the event of a nearby atomic explosion, the State laboratory, as well as those of research institutions such as Harvard and M.I.T., would be called upon to furnish emergency survey teams, to make many analyses at water sources in order to assure protection of water consumers.

Summary

Conventional water-treatment processes will remove radioactivity present as anions, colloids and particulate matter. If isotopes such as strontium and similar fission products should occur as positive ions after an atomic explosion, they would not be removed readily by conventional processes, because special treatment will be required, using double coagulation and sedimentation. Thus, very few water-treatment plants will be equipped to remove large amounts of radioactivity occurring as cations in times of disaster. However, the chances of such contamination are very remote and do not warrant the expenditure of funds for treatment-plant additions.

Water superintendents can do the greatest service to their communities by understanding some of the basic principles of radioactivity, by reading related literature in technical journals, by knowledge of the restrictions facing them by the fixed nature of the plant, by having connections to a number of sources of supply, such as adjacent communities or auxiliary wells, and by assuring their consumers, that, in the event of contamination, natural decay and dilution will substantially reduce the amount of radioactivity in a matter

of days. There is really not much one can do otherwise, from the standpoint of removal of radioactivity from water.

Through the coöperation of the State Health Department, superintendents should be obtaining data on the natural radioactivity in their raw water, if any detectable amounts are present. They can then be in a position to evaluate the extent of contamination, should any occur from bombing, laboratory or medical uses, or from installations utilizing atomic power.

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EQUIPMENT AND RECORDS OF THE WINCHESTER WATER AND SEWER DEPARTMENTS

BY JAMES D. HALWARTZ*

[*Read January 17, 1952.*]

Everyone gets a laugh out of a cartoon showing a plumber at $2.25 an hour running back to his shop for a wrench or piece of pipe. In real life, however, if a water-department employee forgets or does not have a wrench or cannot find the street shut-off, the superintendent is soon told what an inefficient department he is running. So, through bitter experience, a superintendent soon learns to have the necessary equipment at hand and to keep the records up to date.

Winchester, with a population of about 15,500, has 70 miles of mains; there are 1,270 gates, 714 hydrants, 25 sprinkler connections, 15 private hydrants and 4,247 services, all metered. Winchester has its own three reservoirs, with a capacity of 511.2 mil gal, an auxiliary well field of 24 2-inch wells, capable of 300,000 gpd, and a connection to the MDC Turkey Hill Standpipe, from which we draw approximately 200,000 gpd. During the year 1951 the wells have not been used, with the result that 88% of our water has been from the reservoirs, with the MDC supplying the remaining 12%.

The writer believes that there are two things which will make a department run smoothly, with a minimum of complaints; first, equipment with which to do the work; second, records which will show what, where and when you have done work. A study of these and other records will help in planning future work.

EQUIPMENT

Let us look at the equipment needed to get a small department from job to job. Trucks are the prime movers of a department and the right kind of a truck should be chosen for the job to be done. We believe that, if the department is not big enough to support an auto mechanic, a make of truck should be chosen that has an up-to-date

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service shop in your town. A local dealer will be available even at night, if parts are needed. In the Winchester department the superintendent has a ¾-ton truck, equipped with two-way radio and a draw-bar for towing either the small compressor or the sewer-cleaning trailer. This has proved its value numerous times in picking up a crew which has finished a job and moving men and the compressor to another job, without running around and looking for a free vehicle.

The ½-ton meter truck, new in 1951, has a utility body manufactured by the Kiley Co. in Somerville. The enclosed bins on the side have tools, parts, fittings, and space to carry meters. The enclosed center part is used for gate and service keys, picks, shovels and space to carry large meters. As this truck is used by one of our night-emergency men, it carries a stock of repair sleeves, nipples, bushings, couplings and other items which might be needed.

The service truck is a ½-ton canopy-top job and is used by the service crew putting in water services, cleaning services and making repairs to services. As storage for parts, this truck has a box into which are poured fittings, wrenches, hacksaw, cutters and dies. Here we see the difference between the new meter truck and this one. In the meter truck, everything is separated in bins, while in the service truck everything has to be taken out to get that nipple at the bottom of the pile

The reservoir patrol is a ½-ton truck, equipped with two-way radio, fire extinguishers, shovels, brooms and axes.

There are three dump trucks, used on different jobs. One with a draw-bar may be used by the Sewer Division in hauling its cleaning rig; the others, on construction jobs, in hauling needed materials to or away from the job. They are also equipped with plows in the winter-time and used by the Highway Department.

There are two, 1½-ton, flat stake-body trucks, which are used to haul pipe and lumber to jobs. While using Transite pipe, we do not need a derrick to lift the pipe on or off the trucks. The flat-body trucks will carry more pipe than the dump-body trucks. These trucks, too, are equipped with plows and used by the Highway Department.

We also have two compressors: a truck-mounted 105 and a trailer-mounted 95. The trailer job is used mostly on service work, breaking pavement and small stones, and boring holes through founda-

tions for service pipe. Each compressor is equipped with a paving breaker and a jack-hammer. The small compressor also has a clay spade. With our jack-hammers, we now have carbide bits. These new bits cost much more, but the amount of work turned out more than offsets the cost.

We have an International Farmall tractor with a double-acting front-end loader that does about anything in the department. This unit digs, backfills, lifts pipe, sets hydrants and holds them in place to be braced, removes snow from around hydrants, and loads sand, gravel and snow into trucks.

We have a thawing machine, which is a Ford motor running a generator. As we do not use it too often, it is kept in the Highway Department yard and used to do all of their welding. There are two block-tin coil steamers, which are used to thaw out services. We also have a steamer, purchased this year, to thaw frozen hydrants if necessary.

There is a large tapping machine, with cutters ranging from 6″ to 10″, two service-tapping machines and a D-type machine, which is used to bore out corporations when cleaning services.

Here we might stop to argue a bit. Until two years ago, a charge was made to clean a service. In trying to collect on some of those which were done, it became a nuisance charge and the charge was abolished. With no publicity on our part, the number of services to be cleaned jumped to the point where two crews, composed of two men each, cannot keep up with the work.

The hand diaphragm pump was put aside years ago for centrifugal pumps, which are all right if there is a large amount of water in the trench. The Department has two 3-inch centrifugal pumps working most of the time. A small, 1½-inch, throttle-controlled centrifugal pump was purchased in 1950 and did a wonderful job on service leaks, because it could be throttled down to hold just a small amount of water in the trench. Two motor-driven diaphragm pumps were purchased this year. They have proven to be very handy on small leaks.

We have a 1,500-watt Homelite generator, with two 500-watt floodlights and one 250-watt spotlight. There are also taps to plug in extension cords, for use down in tunnels.

The Department switched to copper tubing as a service piping

a few years ago, and now we have to have a good supply of tube cutters and swedging tools on hand.

When the Department started using Transite pipe years ago, the only way in which to cut it was with a saw. There was always the fellow who forgot to have the saw sharpened and some of the cuts became a real chore. Today we have a real commercial pipe-cutter and the old wooden saw-horse is used to hold the pipe while cutting it.

Plenty of caulking tools, hammers, snakes or joint runners, and stacks are a must in equipment for pipe work. We have a power saw for cutting blocking on a rainy day. All furnaces, pots and ladles should be kept in good shape. A wide assortment of wires and rods, a force pump and a coil spring run by an electric motor are used for cleaning water services. The equipment used depends on the type of service pipe and on the man doing the job. Some prefer the wires and others prefer the rods. Everyone uses the coil spring on short services, as it does a good job more quickly and is easier on the men.

We believe that, while not normally called equipment, a department should have a supply of repair sleeves of all sizes, and wrenches should be available to fit the nuts and bolts. Hydrants and hydrant parts should also be available.

The testing equipment in the meter shop was built by employees of the Department years ago and consists of a Fairbanks scale, a steel tank and a bench. To this has been added a yoke for the testing of large meters. Some day, when we really get rolling on a five-year testing program for meters, we shall need a regular testing bench.

In case of failure of the pipe line from the Metropolitan District Commission source at Turkey Hill, there is a standby pump on High Street, with its suction supply from the gravity system.

On the East High Service System, there are two pumps, one taking its supply from the North Reservoir and the other from the South Reservoir. Each one supplies about one-half of the demand on the East High System. In case of failure of either of the pumps, by opening the division gates one pump can supply the whole system.

In the well field, there are two pumps and motors. When the station is in operation, each one is run for a week at a time, so that there is always a standby unit.

At the North and South Stations, the chlorinators have duplicate standby units. There are comparators for pH values and for residual chlorine available. One set is in the meter truck and is used each day. We also have a Schwarzenbach titration kit for the determination of total hardness. This is used mostly to convince the washing-machine people that we do have a soft water.

This year, we hope to sell the Finance Committee the idea that we should have a small backhoe to use in service work.

In the way of small equipment, a department should have the following:

sharp picks	hand tampers	leak finders
pick handles	air tamper	measuring tapes
bull points	tunnel shovels	trench braces
bars	wrenches of all sizes	danger signs
shovels	striking hammers	trench horses
spades	sledge hammers	lanterns
rakes	dog chisels	bombs
rubber boots	pipe cutters	service keys
rubber suits	pressure gauges	gate keys
suction hose	hydrant pumps	hydrant wrenches
discharge hose	aquaphones	pipe finders
box cleaners		

Several 110-volt sump pumps will come in handy. In Winchester we lend these to the customer, if he requests a pumping-out job.

Records

Now that the work is done, do we know what we have done and where it is? In coöperation with the Engineering Department, all mains, gate valves, hydrants, services and service boxes are tied down and plans and sketches drawn. The Engineering Department keeps all master plans up to date and duplicate street sheets are in files at the shop office.

There is a location of each service shutoff at the shop office on individual 5″x8″ sheets, bound in loose-leaf books. This past year, in connection with civil defense, three sets of half-size plans were made and bound in books, which will give each civil-defense emergency crew a set of plans to use instead of running to the

office for locations of gates. The local Department of Civil Defense paid the cost of these plans.

When each service is installed, a service card is made out. On this card is the street address, district, kind of pipe, length on the property and in the street, and the size, make and serial number of the meter, together with information about when the service was cleaned and recommendation about renewals, if it is an old service. A small marker is placed on the service card of an unmetered new service. Once a month, a list of these services is compiled and checked as to reason for being unmetered.

A meter folder is also made up. Into this folder goes all future meter-test records. On the test record is noted information as to accuracy, readings before and after the test, parts used and cost of repairs.

In books at the shop office are kept records of all costs of jobs, from main extensions to winter hydrant inspections. Each man's time for the day is broken down to Water Construction, Water Maintenance, Sewer Construction and Sewer Maintenance.

A record is kept of what gate valves are closed and for what purpose. A separate set of loose-leaf books is kept up-to-date on each gate-valve and hydrant inspection or operation. From this record we know which will need attention in the future. A map of the entire system is pinned in such a way that the emergency man will know which division gate valves are closed.

The meter man visits each water- and sewage-pumping station daily. He records the electric meter reading and the water-meter and counter readings. From this information, the shop clerk computes the production figures for the previous 24-hour period. The reservoir elevations are also taken every day. During the summer months, the use of these two figures will show where the greatest demand is and steps will be taken to change the division gates to supply this demand. Rainfall is gauged and plotted, and from this chart cycles can be determined. Pressure charts for each station, changed daily, are filed. In connection with this, a year ago we had a bad fire in a wooden block in Winchester Center. When the third alarm was sounded, our division gate valves were opened and the screens were checked at the gate houses. Seven hydrants were used, with a pump on each. The

Fire Department seemed to have all the water they required and the fire was brought under control. Some time later, an insurance underwriter visited our office and wanted to know what the fire had done to our system. We showed him our production figures, taken from our master meters and our pressure charts. He was quite impressed that this information was available and that we were in a position to supply such a demand. Of course, some of our customers, including a commercial laundry, were not so impressed, as they got some rusty water.

It was with such records as these that the Water Commissioners were able to sell the Finance Committee back in 1938 that the auxiliary wells were needed. They were installed and in 1939 and 1940 came in very handy, as at that time we did not have a connection to the Metropolitan District Commission supply.

The records also show that we shall not be able to keep supplying the demand on account of the rate at which the town is building up and the Metropolitan District Commission is making a study as to how best to supply the town. Here, too, our records show just where and when we need the most water and the Metropolitan District Commission will be able to design a supply line to satisfy the demand.

As we have not been able to sell the idea to the Fire Department, the Water Department makes the winter inspection of all hydrants. While we work in close coöperation with the Highway Department, some of their employees forget to inform us when they open hydrants. With tree-spraying operations, street sweepers and cement mixers moving all over town, it is necessary to keep a very close watch on hydrants from the month of November on through the winter, to make sure that there is no water left in hydrants after use. All hydrants that leak or whose drip rod does not function are marked for repair in good weather and a close check is kept on them until they are repaired.

Each man going on a job has a shop order to do certain work. When the job is finished, this order is turned in with the employee's time and material used. This system applies to all work from reading a meter to putting in a house service. Each man also turns in a time slip for the day, showing where he has been and the number of hours worked.

The writer is one of those unfortunate souls who not only have to supply the water but have to get rid of the waste materials afterward. Almost the same sort of equipment is used in the Sewer Department as in the Water Department. Trucks and piping, etc., are the same. We do our own cleaning with our own equipment. This equipment consists of two sets of house-cleaning rods and one set of main-cleaning rods. The main rods are carried on a reel, which is mounted on a trailer. This trailer is towed out to the district to be cleaned.

Records are kept of mains which have to be cleaned more than once a year and, by cleaning these regularly, we eliminate stoppages which may cause trouble in houses. For house services which have to be cleaned yearly, we recommend renewals.

In the beginning, I said that there were two things that made a department work and at this time I wish to add a third. No matter how hard you work to keep a department up to snuff, there will come a time when you will need help and you will turn to your neighboring superintendent. Therefore, a third thing to remember is to keep friendly with him or them and they will always help you out.

In closing, I should like to give credit to the man who designed all the records used in our department. When he took office, most of the records were in person's heads and not on paper. In the course of his more than 35 years of service, he brought the Department up to the point of efficient service which it renders the townspeople and the Department is a monument to a man who served his town well. I refer to the late Edmund C. Sanderson, who was chairman of the Water and Sewer Board for 34 years.

CHLORINATION AND BACTERIAL PROBLEMS IN THE DISTRIBUTION SYSTEM

BY CLARENCE H. REED*

[*Read at Chemists' Round Table, Feb. 14, 1952.*]

Chlorine treatment was started in parts of the M.D.C. supply in 1928. Continuous chlorination of all water delivered to the distribution system commenced in 1930 at the entrances to the Weston and Sudbury Aqueducts.

Chlorination of all water leaving the open distribution reservoirs, which is a second or third treatment, was started on the following dates:

Spot Pond, the largest distribution reservoir—1932;
Chestnut Hill Reservoir at Pumping Stations 1 and 2—1935;
Waban and Fisher Hill Reservoirs—a third treatment—1935;
Fells Reservoir—also a third treatment—1940;
Bear Hill—a third treatment—1941.

Hypochlorinators were used at the small installations when treatment was first started. These, together with manually controlled chlorinators, were replaced by automatic chlorinating equipment between 1936 and 1946. Automatic chlorinating equipment has been placed in service at our two largest installations within the past two years. All chlorinating equipment is operated in proportion to the flow and actuated by a differential, created by the use of Pitot or piezometer tubes and converters. At one installation, floats and an air transmitter are used.

The use of ammonia with chlorine was started in 1932 at the old Sudbury Aqueduct, and at the other initial treating plants in 1938. We should prefer not to use ammonia, but find it difficult to operate without it. By using ammonia, we can retain a chloramine residual for more than 24 hours. The ratio of ammonia to chlorine used is one part ammonia to four or five parts of chlorine.

We discontinued the use of ammonia for short periods of time,

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but on each occasion we received numerous complaints of chlorinous taste in the water. We find that the use of ammonia in our supply improves the bacterial results during the summer months and helps eliminate chlorinous taste in winter. We have experimented with chlorine-dioxide treatment in place of chlorine-ammonia treatment with good results, but found the process expensive.

The amount of chlorine used for initial treatment varies from 1.5 ppm during the warm months to a little less than 0.50 ppm during the cold months. The total residual after 10 to 15 minutes varies from

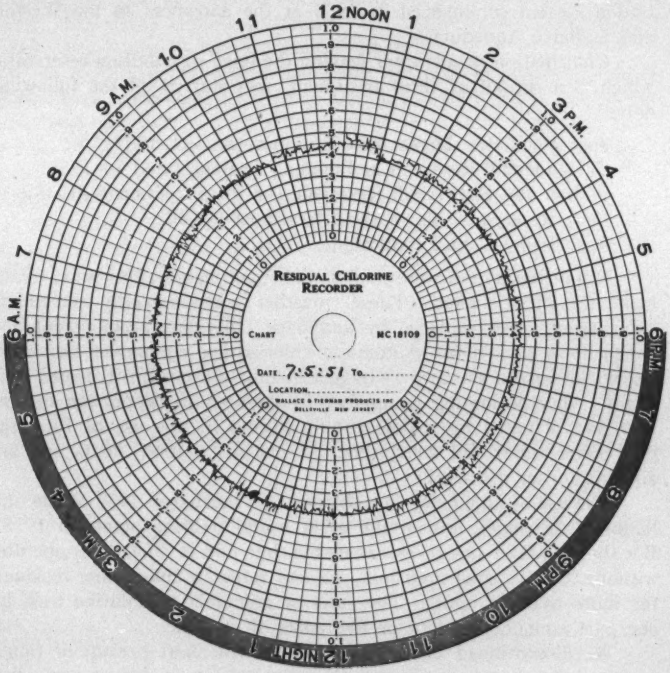

FIG. 1.—RECORD OF RESIDUAL CHLORINE, JULY 5, 1951.

a little more than 0.50 ppm during the warm months to approximately 0.25 ppm during the cold months.

A residual chloramine is carried throughout most of the distribution system. There are some remote sections where it is difficult to retain a residual. The free or O.T.A. chlorine residual varies from a trace to 0.10 ppm at the initial treating plants. The time required for the water to reach the first consumers after the initial chlorine-ammonia treatment is at least four hours.

We have residual-chlorine recorders installed at our initial treatment plants. The accompanying charts (Figures 1 and 2) show

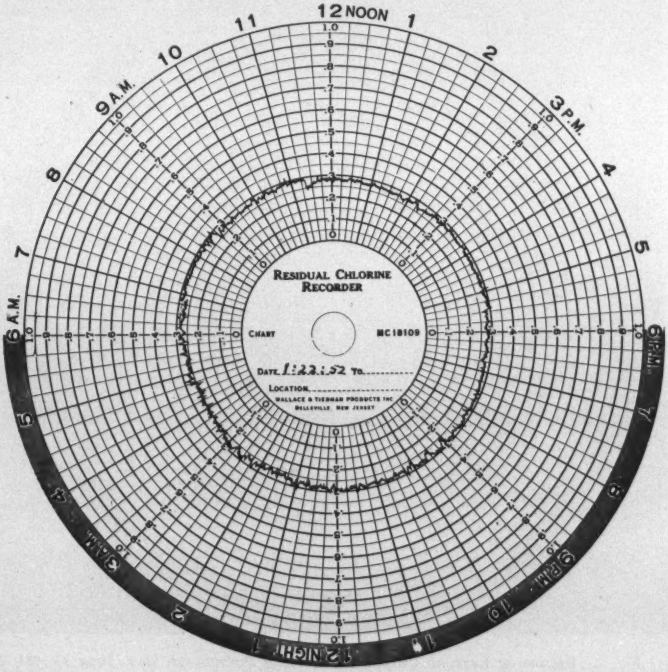

FIG. 2.—RECORD OF RESIDUAL CHLORINE, JANUARY 22, 1952.

chlorine residuals continuously recorded over 24-hour periods; the chlorine rate-recorder charts for the same periods (Figures 3 and 4) show the variations in the amount of chlorine used to retain a fairly uniform residual. The variations in chlorine rate are due to the changes in flow.

All new or repaired pipe lines are chlorinated with either hypochlorites or liquid chlorine. We plan to use 50 ppm, but have used as much as 100 ppm. In chlorinating some of our largest aqueducts

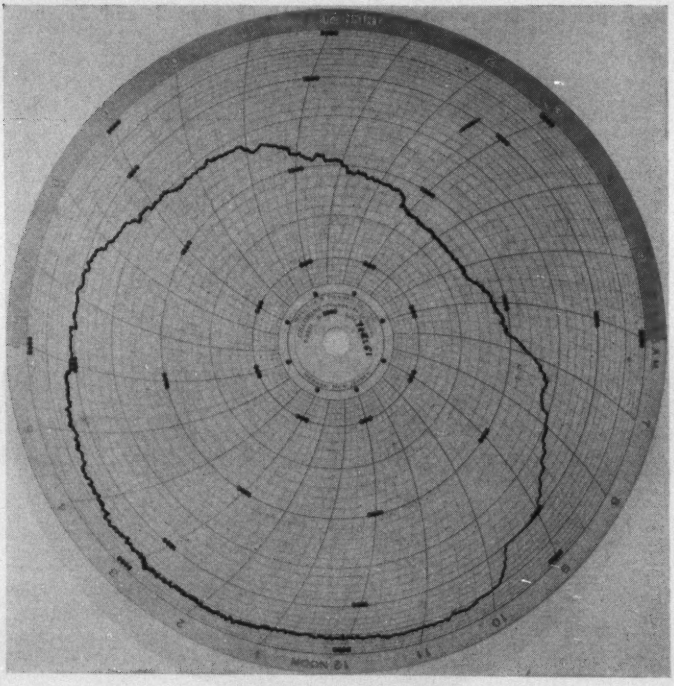

FIG. 3.—RECORD OF RATE OF CHLORINE DOSAGE IN POUNDS PER DAY, JULY 5, 1951.

and tunnels, we have been required to lower the amounts to 35 or 40 ppm. For two jobs, we purchased all the sodium hypochlorite we could obtain in this vicinity. For one treatment, 5,775 gal of NaOCl, equivalent to 6,165 lb of chlorine, were used and for another 6,357 gal of NaOCl, equivalent to 6,789 lb of chlorine, were used. Sodium hypochlorite was used because these large amounts had to be applied within a period of about 36 hours and we had no means of discharging liquid chlorine at that high rate. We use a trailer chlorinator on

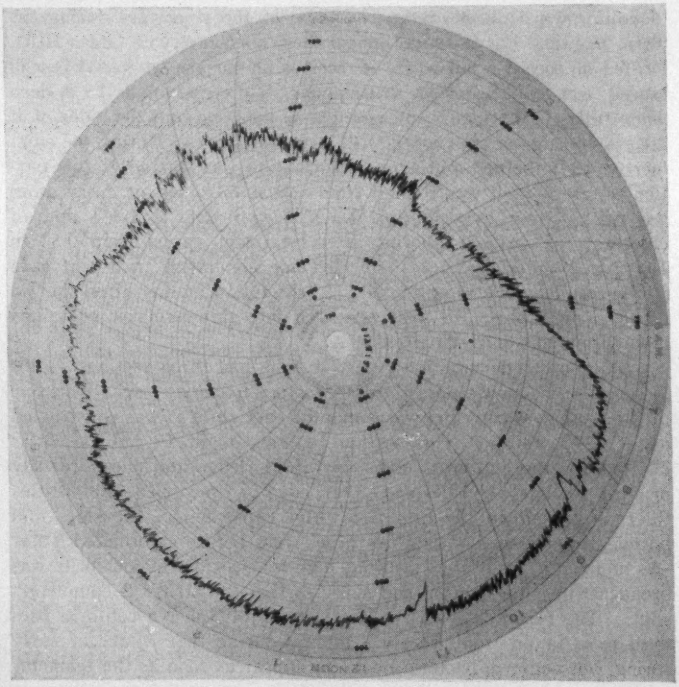

FIG. 4.—RECORD OF RATE OF CHLORINE DOSAGE IN POUNDS PER DAY, JANUARY 22, 1952.

most of our average-size pipe lines—from 20 to 60 in. in diameter. Pipe lines are usually treated while filling and, in most cases, are flushed before and after treatment. The pipe lines are not put into service until they give satisfactory bacterial results. Sometimes we have to resort to a second treatment, in order to obtain the required results.

The bacterial results obtained by extensive sampling throughout our distribution system are not always what we desire. The chlorination of our open distribution reservoirs was brought about by growths of coliform organisms present in some of the reservoirs during the warm months. For instance, our smallest open reservoir (Bear Hill), located on top of a hill where it receives no surface wash and is well fenced, was troublesome in this manner. This reservoir is 15 ft deep when full; the bottom is either ledge or concrete and the sides of it are either ledge or rip-rapped with large flat stones. During the summer of 1941, before continuous chlorination was started at this particular reservoir, it was treated from a boat 68 times, or every other day, with sodium hypochlorite (NaOCl) equivalent to 1-1½ ppm of chlorine; the residual chlorine after treatment varied from 0.50 to 1.0 ppm. Bacterial samples collected one hour after treatment gave sterile results, while samples collected the following day often showed coliform organisms. All water pumped into this reservoir contained a small amount of residual chlorine.

In another distribution reservoir that has three sections (Fells Reservoir), we have obtained unsatisfactory bacterial results from one of the sections during the warm months ever since it was constructed about 12 years ago. This section contains about 19 mil gal; it is 20 ft deep; the bottom is about two-thirds ledge and one-third clay or hard-pan, and the sides are either ledge or rip-rapped. Before this reservoir was filled the first time after construction, the sides and bottom were flushed with a fire hose. Just before chlorinated water was pumped in to fill the reservoir, high-test calcium hypochlorite was broadcast over the bottom and sides, so that the area was completely white. The first filling was in late October, 1940. No coliform bacteria were found from weekly sampling during that winter or early spring, but coliform bacteria began to appear as soon as the temperature approached 60° F. Frequently, during warm months, they are

present in dilutions with 0.1 ml and are occasionally found in dilutions with 0.01 ml. During the past few years, we have shut this section of the reservoir out of the system during the summer and fall months. This is accomplished by simply closing a 24-inch valve.

One interesting point we have observed in some of the distribution reservoirs is that the concentration of coliform organisms varies with the amount of circulation. (The reservoir just mentioned has very little circulation.) The bacterial results are better in the reservoirs which have good circulation, obtained either by a flow of water through them or by a considerable change in elevation, whereby they drop a few feet during high consumption each day and are filled again during the night.

The reservoir first mentioned (Bear Hill) gave poorest results during a period when the elevation was kept quite constant. During the past few years, the variation in elevation has been greater and consequently greater circulation resulted, with a marked improvement in bacterial results.

There has been no warm-weather bacterial problem in our one large distribution reservoir that has complete circulation by means of a flow of water through it. Most of our distribution reservoirs ride on the line; the water enters and leaves through the same pipe at the same place. A new reservoir (Blue Hill), recently completed, is so constructed that any inflowing water is piped through the gatehouse to the far end, in order to give complete circulation through the reservoir before it is drawn out. This is accomplished by the use of flap gates, which are similar to check valves and which open or close according to the direction of flow.

During the late summer months of 1950, we experienced one of our worst blossoms of coliform organisms in a section of our distribution system. At the same time, an unusual growth was observed in one of our storage reservoirs. As a rule, coliform organisms are absent where there is any chlorine residual, but these organisms seemed to have marked resistance to chlorine treatment. At other times, we have experienced coliform growths in small sections of our system, mostly in dead ends or remote sections, where it is difficult to retain a chlorine residual.

Results of differential tests indicate that the coliform organisms when found in the distribution pipes are Aerobacter aerogenes (Methyl-red negative, Voges-Proskauer positive and Koser-citrate positive). While those found in some of the distribution reservoirs may vary, they are mostly Aerobacter aerogenes, but there are also intermediate types and E. coli.

Since November, 1950, we have by-passed the Sudbury Reservoirs by the use of a tunnel and have drawn the entire M.D.C. supply directly from Wachusett Reservoir. The water is drawn from mid-depth of the reservoir and during the warm months the temperature in the distribution pipes is 8° to 10° F. colder than in previous years, when Wachusett water passed through the Sudbury Reservoirs.

Organisms causing spurious tests in lactose broth during cold months are practically absent in Wachusett Reservoir water. The average weekly samples collected throughout the year had a coliform-index M.P.N. of less than 2.2 before this water was treated with chlorine.

During 1951, the bacterial results of weekly samples collected from taps throughout the distribution system were most satisfactory.

Reasons for not resorting to super-chlorination or breakpoint chlorination are as follows: If it takes from a few months to a year to clean up a small system, how long would it take to clean up the M.D.C. supply? Our customers are not very tolerant to chlorinous or any other taste. Also, numerous old places that have lead-pipe services have to be considered.

At the present time, we have more than 50 sampling places in the distribution section where samples are collected at least once a week. We usually use fire stations, police stations and gasoline stations.

Samuel O. Swartz, our bacteriologist, has made some interesting observations in regard to microscopic organisms acting as host to bacteria. From these observations, he is of the opinion that the gelatinous coating of some of these organisms prevents the residual chlorine in the water from coming in contact with the bacteria.

Discussion

Samuel O. Swartz* (Boston, Mass.)—In August, 1950, coliform bacteria were found to be present in a section of the Metropolitan District Commission water pipe-lines. An increase in the chlorination did not seem to have any effect, except in the immediate area of treatment.

Temperature of the water at this time was 70° F. When the temperature went down to 60° F., the bacterial condition disappeared, except in the outlying sections of the system, where the condition persisted until the temperature went down to 55° F.

At the time the bacterial condition was observed, I noted the presence of a growth of *Gloeocystis* (Chlorophyceae Class) and *Chroöcoccus* (Cyanophyceae Class) in the reservoir.

I observed at this time that these algae passed the point of chlorination, 0.75 ppm residual chlorine, and continued on in the distribution system, where I picked them up at a tap ten miles away from the reservoir.

I filtered two liters of tap water, concentrated the residue to 5 cc, placed some of this material on a glass slide to air-dry, and Gram-stained the sample. Microscopic examination revealed the presence of various bacteria within the gelatinous mass of organisms found to be present in the concentrated tap water.

I repeated the same procedure with samples of water from the reservoirs and found bacteria in various forms of algae. I observed that microscopic organisms are carriers or hosts to various forms of bacteria while on the surface of the water.

At peak water demand, the gelatinous masses of algae and clumps of organic material which harbor bacteria pass the point of chlorination and disintegrate farther out in the water system, where there is not enough chlorine to eliminate an after-growth.

A series of samples was made by running chlorinated tap water through a sterile tap filter for 12 hours. The accumulated material was put into a sterile flask with glass beads and rotated and shaken for five minutes. Ten ml of this material were introduced into lactose-broth tubes.

Gas formation developed in all tubes in 36 hours. Positive coli-

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form results were observed in some of the samples, which showed the presence of a variety of coliform members. The temperature of the water was 75° F.

Another series of samples was run in December and January; all samples showed negative results. The temperature of the water was 45° F.

A sample of material accumulated on an aqueduct screen before treatment was placed in a sterile bottle and some chlorinated tap water was added (residual chlorine, 0.30 ppm). Bacterial examination showed the presence of gas in lactose broth in ten hours. Cross-inoculation to E.M.B. agar showed typical green sheen and button-shaped colonies of coliform bacteria.

Another sample of accumulated material was treated with chlorine until it showed negative in lactose broth. After three days, the treated sample was introduced into lactose broth; gas was noted in 24 hours. Cross-inoculation to E.M.B. agar showed typical colonies of coliform bacteria in the completed examination.

An IMVIC examination showed the following results:

Koser citrate media	= +
Voges-Proskauer test	= +, some —
Methyl red test	= —
Tryptone medium	= indole +

Results of the above test would indicate that accumulative material acts as a shield, so that the chlorine cannot penetrate to kill all bacteria present in a mass of organic matter.

After searching for some information on this subject, I found the following:

"Microscopic examination will often show collections of millions of bacteria in close contact with certain forms of active living algae (1).

"Zoögloea-like masses are sometimes visible to the naked eye and can be isolated and examined. Most vigorous shaking often fails to disintegrate them. One sample of water examined before shaking gave 860 bacteria per c.c.; 4800 per c.c. after a very vigorous agitation."

"The gelatinous material is resistant to disintegration and tends

to bind sand particles (2). Of more interest is the fact that it is apparently resistant to the penetration of chlorine or chloramines. Coliform bacteria, *Pseudomonas pyocyaneus, Salmonella,* and other suspected pathogenic bacteria have been isolated from macerated preparations of such algae when none were found in 100-ml. samples of the reservoir water."

During my investigations, I inspected various Metropolitan District Commission pipe lines, which had been opened up for repair, and found a good many of them to be quite clean except for tuberculation, which I found encrusted on the inside of the pipe.

I pried some of the tubercles off and placed them in a sterile bottle. Bacterial examination showed coliform bacteria to be thriving in the tubercles.

A chemical examination of the tubercles showed the following results:

Moisture	= 26.75%
Volatile matter	= 16.53% (dry basis)
Total iron	= 22.3%
Ferrous	= 11.8%
Ferric	= 10.5%
Sulphur	= 0.428%
Silica	= 1.21%
Nitrogen as albuminoid	= 0.0733%
Total organic nitrogen NH_3	= 0.1466%
Protein N	= 0.1466×6.2

The chemical examination indicates a favorable area for the development of bacteria in a pipe line.

Further studies relating to the above problems are being pursued at our laboratory, regarding the presence of coliform bacteria in distribution systems after chlorination.

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Dr. Shih L. Chang, Department of Sanitary Engineering, Harvard University.

WATER-SUPPLY CONTROL IN RETROSPECT
A BRIEF REVIEW

BY CHARLES R. COX*

[*Read February 14, 1952.*]

Public water-supply systems embrace so many structures, and the supervision and operation of such systems involve so many diverse technical specialties that, for the sake of brevity, this brief review will be restricted to significant aspects of the protection and treatment of public water supply in New York State, so as to insure the delivery of water of attractive character and safe sanitary quality.

The protection of upland sources of public water supplies has been well established in the northeastern part of the country, where natural conditions are favorable to securing relatively clear and attractive surface supplies, subject to limited pollution. This favorable situation created an opportunity for significant benefits from protective measures during the period prior to the era of water treatment. It is not surprising, therefore, that the first act of the New York State Legislature in the field of environmental sanitation was the enactment of a law in 1880 establishing the procedures by which the State Commissioner of Health promulgates rules and regulations for the protection of sources of public water supply.

Such rules have been enacted to protect about 230 public supplies in the State. Experience has shown that such rules are quite useful in minimizing the degree of pollution of natural waters, even though they cannot be enforced so as to prevent pollution which may result from the *legitimate* use of property and riparian rights—that is, except where the pollution can be held to menace public health and warrants action under other provisions of the Public Health Law. Such rules, however, are valuable in establishing guiding principles for those owning property on a protected watershed and also for water-works officials charged with the duty of protecting specific sources of water

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supply. Violations of the rules are corrected on a local level in most instances, but when necessary the remaining violations are confirmed by a public health engineer. The State Commissioner of Health orders the abatement of confirmed violations by the local health department having jurisdiction.

Such rules and regulations are not suitable for the protection of large rivers or lakes, nor can they be used to protect waters which are not currently in use as sources of a specific water supply. Therefore, as early as 1903, legislation was enacted to require a permit from the State Commissioner of Health for the discharge of sewage or industrial wastes into the waters of the State, which power permitted requirements as to degree of sewage and industrial-waste treatment as conditions of such permit. This legislation is still in force, but in 1951 the Water Pollution Control Board was created, to study more effectively the natural waters of the State and to determine classification of specific streams, which would serve as a basis for requirements as to sewage and industrial-waste treatment. Present planning is to complete this work by 1959, when the 1903 legislation will be superseded by that of 1951. In the meantime, both acts have been coördinated by administrative procedures. These developments are mentioned here because all of these activities serve as the basis for the protection of existing or potential sources of public water supply, bathing beaches and shellfish areas and, therefore, are the first step in the control of public water supplies, not to mention other important benefits.

Changes in the protection and treatment of public water supplies through the years have occurred so gradually that profound changes have resulted without being evident from year to year. As noted above, almost complete dependence in the past had to be directed to the protection of water supplies, until filtration began to be developed after the 1895-1900 period, the filtration plant of the city of Poughkeepsie, constructed in 1872, being an exception. Of more immediate significance in the past, however, was the development of water chlorination in 1908 and its more extensive utilization following 1912. It was not until 1918, however, that the Orthotolidine Test was properly applied to the routine control of chlorination. Thereafter, less attention had to be directed to protecting sources of supply, as the

practice of filtration and chlorination became the chief tools for minimizing waterborne diseases.

Explosive outbreaks of waterborne diseases, however, continued to occur and directed attention to failure properly to utilize available facilities or technical procedures—that is, attention was directed to those in charge of such facilities. Schools for water-treatment plant operators, therefore, were inaugurated in New York in 1927, to improve operation and control.

Since it was found, however, that trained, experienced operators at times were replaced by inexperienced individuals for political motives, in 1937 the State Sanitary Code was amended to require that operators of water-treatment plants have Certificates of Qualification from the Public Health Council, designed to protect competent operators from being replaced by incompetent operators for political motives and also to stimulate the employment of properly trained and qualified operators. These developments again emphasize the fact that a trained, resourceful operator may secure effective results with antiquated equipment, whereas less qualified operators may allow modern treatment plants to deteriorate rapidly and produce inferior results.

Waterborne Diseases

Prior to 1928, when waterborne typhoid-fever outbreaks were occurring in New York State each year, experience showed that there were approximately ten cases of typhoid fever for each death from typhoid fever and that there were ten cases of gastroenteritis for each case of typhoid fever. Therefore, in those days, the prior occurrence of gastroenteritis, with an incubation period of 24 to 72 hours, served primarily to draw attention to the probable occurrence two to three weeks later of typhoid fever, little concern being given to the gastroenteritis cases. Since 1928, however, there has been only one outbreak of typhoid fever in the State traceable to public water supply; namely, that in the city of Rochester, where through error untreated Genesee River water was pumped through an illegal cross-connection between a separate fire supply and the main, potable, public water supply of the city. It is significant that approximately 30,000 cases of gastroenteritis were followed by only five cases of typhoid fever, with no

deaths from this disease. This has been interpreted as indicating that the raw Genesee River water was contaminated with organisms causing non-specific gastroenteritis, but that the few remaining typhoid carriers in the population residing on the watershed of this sizeable stream had led to a material reduction in the degree of contamination of the river by S. typhosa. In any case, had this outbreak occurred 10 to 20 years sooner, the number of typhoid-fever cases might readily have reached 3,000 with about 300 deaths.

The marked reduction in the occurrence of waterborne typhoid fever obviously made it necessary to give attention to the gastroenteritis which continued to occur. It was found that the gastroenteritis formerly was in the nature of mild bacillary dysentery. Since 1938, however, the incidence of bacillary dysentery in the State also has been greatly reduced and this disease no longer presents a problem in the control of public water supplies. On the other hand, gastroenteritis continues to occur to a limited extent and current studies, which are not completed, indicate that one or more viruses may be involved. Circumstantial evidence supports the conclusion that conventional chlorination of public water supplies destroys the virus; otherwise, gastroenteritis would be endemic in communities served by supplies secured from polluted streams and subject to such conventional treatment.

As a net result, the typhoid-fever death rate for the State as a whole has been reduced from 26.8 in 1900 to 15 in 1910, 3.5 in 1920, 1.2 in 1930 and 0.3 in 1940 per 100,000 population. The current rates from year to year are zero to about 0.1 per 100,000 population.

The number of known typhoid carriers in the State increased from 262 in 1931 to a maximum of 480 in 1944, since when the number has decreased to 394 in 1951. This, of course, is due to the fewer carriers incidental to fewer cases of the disease and also to the death of carriers. It is significant that about 60% of the recorded carriers now are over 60 years of age. It is very evident, therefore, that sewage pollution of sources of water supply progressively is less likely to be accompanied by contamination of the waters with S. typhosa. Remaining cases of enteric diseases, therefore, are seldom associated with potable waters, but are due generally to inferior sanitary conditions, where carriers have an opportunity to contaminate food. We

approach a period, therefore, when typhoid fever will be eliminated from areas where modern sanitation is advanced—a repetition of the experiences with cholera.

Consumers served by public water-supply systems now demand attractive water of safe sanitary quality. Chlorination to produce a safe water may result in the delivery of unattractive water, especially if disinfection is expected to accomplish ends that only filtration and chlorination with taste- and odor-control measures could produce. Therefore, the production of a safe water cannot be separated from the production of an attractive water. Industrial consumers also are more critical and are demanding water which meets diverse industrial requirements. Frequently these needs conflict, because it is impossible to deliver water which, for instance, is non-corrosive and yet has a very low mineral content demanded by many industrial consumers. Fortunately, however, the growing technical skill of water-works personnel and the increased effectiveness of equipment and facilities available to them have enabled the delivery of water which is much more acceptable than was the case in the past. Nevertheless, the morbidity rates referred to above indicate that public health requirements are being met to a degree which is in advance of the present accomplishments in the delivery of water of attractive physical character and which is non-corrosive. In fact, taste and odor control and corrosion prevention remain as distinct challenges to the water-works profession. Tools and procedures are available which are not being utilized to anything like the extent needed.

Therefore, a brief review of significant developments in the supervision and operation of water works may be of interest at this time. Obviously only selected examples can be discussed and many developments will have to be ignored.

Copper-Sulphate Treatment

The development of copper-sulphate treatment for algae control in 1904 has not resulted in the extensive attention to the economical and effective distribution of the chemical throughout the water being treated. Therefore, the general practice is for copper sulphate to be dragged through reservoirs by attaching bags of the material to the sterns of rowboats or small motor boats. The village of Liberty, N. Y.,

however, is using a fruit-tree duster, costing $178 some years ago, for the scattering of powdered copper sulphate over the surface of the stored water from an outboard motorboat, 14 ft long. It appears that the dust can be driven over 100 ft, this method thus permitting the treatment of shallow areas which cannot be reached by the boat. The fine, granular or "snow" type of copper sulphate is used, which costs somewhat more than the lump form.

The city of Newburgh uses a blower, driven by an inboard gasoline engine, also used to propell a small motorboat. Three men are used to man the boat; one to operate the engine and steer, and two to fill the hopper with copper sulphate from 100-pound bags. The dose of copper sulphate is regulated by controlling the boat's speed and the rate of delivery of the chemical to the blower. The size of the copper-sulphate grains is selected so that fine material is used for the surface organisms and the granular material is used for destroying the deeper-lying organisms.

The city of Syracuse since 1938 has been using equipment of its own design to treat Skaneateles Lake, its source of supply, with a solution of copper sulphate. Briefly, the chemical is placed in a hopper, from which it is fed by a motor-driven drum to a dissolving tank, the speed of the drum determining the rate of feed. A low-head centrifugal pump, driven by the boat engine, draws water from the lake through the dissolving tank. The solution is forced by a high-pressure gear pump through spray nozzles, attached to outriggers on the stern of the boat. The spray covers an area about 50 ft wide. Experience has shown, however, that the boat can be operated over parallel courses, 700 ft apart, and yet can secure reasonably satisfactory distribution of the chemical. The whole lake, about 15 miles long and about ¾ mile wide, on the average, can be treated with 11 tons of copper sulphate in 16 hours by operating the boat at a speed of 10 miles per hour.

Multiple-Gate Intakes and Water Quality

An example of the intelligent use of facilities for purposes other than those originally intended is the practice of the Water Department of the city of Albany in securing water through one of three gates located in an intake structure where an impounding reservoir is about 60 ft deep, the selection of the gate depending upon the quality

of the water at various depths. During most periods of the year, the upper intake gate is used to secure the most attractive water available, especially during the winter season when algae growths are at a minimum. During the summer season, however, when there is a demand in the city for cool water, the lowest intake gate, located at a depth of about 48 ft, is used. While the deeper water is free from algae common to surface waters, nevertheless it is devoid of oxygen and contains as much as 3.0 ppm of manganese. The use of cool water, therefore, is accompanied by the problem of effective manganese removal.

Alum is used for coagulation. The surface waters are coagulated at a pH value of about 6.5 and lime is added to the filtered water, to produce a pH value of 8.0 to 8.5, in order to prevent corrosion. During the summer season, however, manganese removal requires coagulation at a pH of about 9.0. The lime, therefore, is added prior to filtration. Experience has shown that most effective results are secured with lime added to the settled water just prior to filtration.

The city of Oneida does not have a multiple-gate intake structure, but the concentration of iron and manganese in the stored water at the low level of the intake piping has been minimized by opening the valve on the reservoir drain to an extent needed to waste as much water as would otherwise flow over the spillway. Thus attractive surface waters are conserved, while the deep-lying waters of inferior quality are wasted. It is surprising how seldom this simple expedient has been used to eliminate water of inferior physical quality from the lower portion of the reservoirs below the thermocline.

Flocculation

The facilities for the pre-treatment of water at filtration plants, constructed in the early years, seldom included so-called mixing facilities. The development of mechanical flocculating equipment and the technique of pH control of coagulation reactions in the period 1915-1925, therefore, represents a landmark in water treatment. This is generally recognized and is being mentioned here merely to draw attention to the fact that older filtration plants, lacking such facilities, have been reconstructed at moderate cost, to provide effective flocculation, merely by using a portion of the older sedimentation basins

for mechanical flocculators. The reduction in sedimentation period is more than compensated for by improved flocculation.

The same trend was accelerated when the so-called solid-contact or upward-flow basins were developed for lime-soda softening and later used for clarification. Ten such flocculating units have been installed in New York State. Experience has shown that flocculation in the presence of previously precipitated floc greatly accelerates the process. This is especially the case when turbid waters are being clarified. The smaller area of these basins, for instance, permitted the installation of a one-mgd unit in a conventional sedimentation basin of the Williamson Water District originally having a four-hour detention period when operated at a rate of ½ mgd. This change and the doubling of the number of filter units from two to four increased the capacity of the plant from ½ to 1 mgd. In general, experience in New York State indicates that detention periods of 20 minutes for flocculation and 40 minutes for upward-flow clarification may be satisfactory for turbid waters, but that an increase in the detention period of at least 50% is desirable for most installations, to provide a factor of safety, even when activated silica or absorptive clays are used to aid flocculation and produce a rapidly settling floc.

Filtration

The over-standardization of design of rapid-sand filter structures seems to have delayed progress. On the other hand, several significant developments have occurred which are worthy of review. For instance, the development of porous plates, which can be used as false bottoms, to replace pipe underdrains and the gravel layer of existing filter structures provides a means of increasing the freeboard above the sand, which in turn permits an increase in the rate of flow of wash water, where this was restricted by the original design.

In the same way, the development of Anthrafilt in 1933 provided a filter medium which is lighter than sand and which, therefore, can be agitated more rapidly than sand with any given rate of flow of the wash water. Replacement of sand by Anthrafilt, therefore, has permitted the much more effective operation of older filter units, where the wash-water facilities were restricted, but where any increase in the rate of the wash-water flow would have resulted in the loss of sand.

Subsequent developments in so-called surface wash also have been chiefly useful in New York State in improving the operation of existing filter plants. Surface-wash facilities have been found to be much more readily provided than an increased rate of flow of wash water through existing underdrains. At the same time, more effective cleansing action of agitating sand grains has been secured than with the same additional amount of wash water applied through the underdrains.

Rates of Filtration

The unit rate of filtration of two gallons per minute per square foot of filter area has served as a standard for such a long period of time that the rate frequently is assumed to be the maximum permissible rate. Experience in New York State with existing filtration plants has indicated, however, that in specific instances peak demand for water can be met by temporarily increasing the rate of filtration to the range of 2.5 to 3.5 gpm per square foot of filter area. Such peak demands usually occurred during the summer season, when the water was most effectively coagulated with available flocculation and sedimentation basins, even though they had to be operated at the lower detention periods occasioned by the increased rates of flow. In many other cases the character of the raw water or hydraulic limitations of treatment plants would make such an increase in rate of filtration impracticable and unsatisfactory from a public-health standpoint.

It should be emphasized that seasonal increases in rates of filtration in specific instances would not be feasible, were the *average* rate of filtration higher than normal; otherwise the maximum rate would be excessive. In other words, the use of the lower unit rate of filtration of 2.0 gpm per square foot provides factors of safety and also for the possibility of seasonal increases in the rate of filtration. Furthermore, plants such as those in the middle west, treating water from the Great Lakes, where higher than normal rates are used, must be designed with due regard to the character and quality of the raw water, and the design of the plant as a whole must include provisions for assuredly effective pretreatment under continuous technical supervision. Any further increase in capacity of such plants will have

to be met by structural enlargements rather than by still further increasing the rate of filtration.

Generally speaking, therefore, it would appear that the rate of filtration of 2 gpm per square foot provides for desirable reserve capacity and insures reasonably long filter runs and freedom from operating difficulty, especially when continuous supervision is not available because of the small size of the plant. Conversely, any higher design rates of filtration would be appropriate only if the character and quality of the raw water being treated, the rapidity and magnitude of fluctuation in quality, the effectiveness and type of pretreatment, and the character of technical supervision to be provided justify their selection, and then only if there is adequate planning for increasing the capacity of the treatment plant as a whole, including pretreatment facilities, when the quantity of water needed exceeds the capacity of the plant.

For some reason, slow sand filters are considered by many to be antiquated and a relic of the past. Actually, 31 slow sand filters were in use in 1948 in New York State, as compared with 103 rapid sand filters. Experience over the years, since the first plant was constructed at Poughkeepsie, N. Y., in 1872, has definitely demonstrated that these filters are especially effective in the treatment of relatively clear surface waters, such as those in the northeasterly part of the country, as bacteria removal can be secured without pretreatment or without close technical supervision. These filters, therefore, are especially adapted to smaller supplies secured from upland lakes and large reservoirs. On the other hand, the operation of these units is laborious where algae growths are prevalent, as with many relatively clear waters, and slow sand filters are soon clogged where iron and manganese are present to any significant extent This is mentioned because one such plant has failed to give satisfactory results, because its selection was based upon the quality of the water in the flowing stream before an impounding reservoir was constructed. Later, when water was stored over soil containing iron and manganese, the absence of dissolved oxygen in the lower water created conditions favorable for the solution of iron and manganese, which reached the filter beds. This incident again indicates the need of designing treatment plants to meet specific local conditions, rather than using standardized design in the form of "package plants."

Diatomite Filters

Two installations of diatomite filters have been made in New York State for the treatment of public water supplies, following the use of pilot plants to establish needed data. The installation treating the water supply of the village of Cherry Valley consists of two units, each having an effective filter area of 94 sq ft. Ordinarily, they are operated at the rate of somewhat less than 1 gpm per square foot of filter area, which is considerably lower than the rates noted in the literature regarding such filters. Experience has shown, however, that this low rate insures economically long filter runs and over-all effective results. Even though the indications are that higher rates of filtration are still effective in clarification and in bacterial removal, they are not economically justified, because of excessive pressure losses, short filter runs and the need to use an undue amount of diatomite per gallon of water being treated.

The Cherry Valley units are operated with a "precoat" averaging about 3.0 ppm in terms of the total amount of water filtered per run of about 120 hours. The "body-coat" averages about 30 ppm. No coagulation is needed, however, for the clarification of this surface water, which has a turbidity under 20.0 ppm, but a high algae content and some iron and manganese. The presence of manganese has made it necessary to provide acid treatment of the porous, earthenware strainer element at intervals of six months. Metal elements probably would be preferable when iron or manganese is present in the raw water in appreciable concentrations.

The cost of diatomaceous earth at five cents per pound totals about $13.75 per mil gal of water treated. This equals or exceeds the cost of coagulants used with conventional plants, but there is no capital charge for coagulation and sedimentation facilities. Experience is lacking as to the effectiveness of these units in treating a previously coagulated turbid water, but they seem to have promise for the clarification of relatively clear surface waters, because of their small size and simplicity.

The Orthotolidine-Arsenite Test

The use of the orthotolidine-arsenite test to distinguish between free-residual, combined-residual and false-residual chlorine, the latter being due to any effects of interfering substances, has been widely

publicized and the test is being used as a routine in controlling so-called free-residual chlorination, so as to insure effective disinfection. The situation leading to the development of this test may be of general interest.

The water supply of the small village of Cairo, N. Y., is secured from an impounding reservoir, where treatment is by chlorination. An explosive outbreak of gastroenteritis occurred in 1943 which epidemiological studies indicated to be waterborne. At the same time, as the treated water had an apparent concentration of 0.5 ppm residual chlorine, chlorination was considered to be satisfactory. Cases continued to develop the following day, however; the dose of chlorine was increased, to provide a residual of 0.75 ppm, and the outbreak was terminated. In the meantime chemical analysis of samples of chlorinated water disclosed the presence of manganese, which created a false residual of 0.5 ppm. It was very evident, therefore, that chlorination was defective during the outset of the outbreak.

The manganese content of the unchlorinated water was in the reduced form, and hence it was not possible to add orthotolidine solution to the raw water and determine the apparent or false residuals due to the manganese alone.

The chlorination of the water resulted in the oxidation of the manganese and the creation of conditions where the orthotolidine reagent would react with the manganese and also with any chlorine present. Mr. F. J. Hallinan, former Chemist of the Division of Laboratories and Research of the New York State Department of Health, developed the orthotolidine-arsenite test, to provide a means of rapidly determining the error due to interfering substances. A modification of the test made it possible to distinguish between free, active chlorine and combined, less active chlorine, such as chloramines.

Free-Residual Chlorine

Every effort is being made in New York State to stimulate the practice of free-residual chlorination—that is, the control of the dose of chlorine so that all of the residual will be present in the form of free chlorine or, in a more technical term, hydrochlorous acid. In this way, chlorination occurs at the so-called "breakpoint", where the organic matter will have been oxidized and where taste- and odor-producing compounds will have been altered, in so far as possible, into

tasteless compounds. Equally important benefits are that the free residual is available for the disinfection reaction and is not dissipated by further reaction with organic matter, because the chlorine demand of the water has been satisfied. As a result, disinfection is 25 to 100 times more rapid than with combined-residual chlorine or chlorine-ammonia treatment to produce the same concentration. The free-residual chlorine, being stable, persists in the treated water and hence will be present throughout the distribution system, after free-residual chlorination has been practiced sufficiently long to oxidize the slime on the inner surfaces of water mains. This may take several months.

Free-residual chlorination is approached at times in a timid manner, because of prior unfavorable experience with chlorinous tastes. The course of action is to make suitable laboratory determinations as to the results of varying doses of chlorine, so that a dose can be used on a plant scale which definitely will oxidize the taste- and odor-producing compounds and hence prevent the production of intermediate chlorinous compounds, which have a disagreeable taste. The desired results are disclosed by the absence of chlorinous tastes and the presence of residual chlorine in only the free form, as disclosed by the orthotolidine-arsenite test. Water of low organic content may require an increase in the chlorine dose of only 0.5 to 1.0 ppm, whereas polluted water of high organic content may require increases in the chlorine dose of 2.0 to 5.0 ppm over those needed to produce moderate concentrations of combined-residual chlorine. In spite of the advantages of free-residual chlorination, there is a surprising lack of willingness to utilize the process.

Chlorine-Dioxide Treatment

The use of chlorine dioxide as an oxidizing agent for taste and odor control was developed in 1944 by collaboration between officials of the city of Niagara Falls and the Mathieson Chemical Co. This treatment process was found to be very effective in eliminating tastes due to the pollution of the river water by industrial wastes of the phenolic type. Accordingly, the process is being used as a routine procedure for the treatment of other supplies secured from the Niagara River—namely, those of Lockport, Tonawanda and North Tonawanda, N. Y.—and also the supply secured from Lake Erie south of the city of Buffalo by the Western New York Water Co.

The procedure has been to prechlorinate these supplies with chlorine alone and to treat the filtered water with sufficient chlorine and sodium chlorite to produce chlorine dioxide in concentrations sufficient to give a chlorine residual in the range of 0.2-0.35 ppm, except for one of the two supplies of the city of Niagara Falls, where somewhat higher residuals are maintained.

The results of research at the University of Michigan and by the Massachusetts Department of Public Health, indicating that chlorine dioxide is an effective disinfectant, especially with waters of high pH value, led to a modification of the treatment of the main supply of Niagara Falls, having a pH of about 7.8. Prechlorination was reduced, so as to give a concentration of residual chlorine of only 0.1 ppm in the filtered water, which is then post-treated with doses of chlorine and sodium chlorite to produce chlorine dioxide in a concentration equivalent to a chlorine residual of at least 0.15 ppm. This treatment has been found to improve taste and odor control by maintaining no excess of chlorine over that needed to produce chlorine dioxide. The remaining supplies from the Niagara River still are being pre-chlorinated more extensively inasmuch as they are secured from points in the river subject to a greater degree of pollution by sewage.

Fluoridation

This general discussion would be incomplete, were no mention made of the fluoridation of public water supplies in New York State. Briefly, three pioneer research programs in water fluoridation were inaugurated at Grand Rapids, Mich., Newburgh, N. Y., and Brantford, Ontario, in 1945. The Newburgh investigation included complete dental, medical and engineering studies, to demonstrate whether treatment of the supply with sodium fluoride would insure the same beneficial reduction in the incidence of dental decay as when natural waters contain about 1 ppm fluoride ion, and also to demonstrate whether there were any harmful effects occasioned by the consumption of water so treated.

Briefly, the data collected during the period 1945-1951 at Newburgh, when compared with similar data from Kingston, N. Y., the control community where the supply is not being fluoridated, may be summarized as follows:

The so-called DMF rate (permanent teeth decayed, missing or filled) for children 6 to 12 years old in Newburgh was reduced 39% in five years, whereas in Kingston, the rate increased 4%. The 5- and 6-year-old children, who were born in Newburgh in the post-fluoride period, showed the greatest benefits, as 359, or 49%, of 730 children in this age group, who had all of their deciduous cuspids and first and second deciduous molars present, were completely caries-free. This represents an improvement of 170% over the 1944 rate. By contrast, only 30% of children in this age group in Kingston were caries-free.

Equally important, it was found that the treatment of the Newburgh supply did not disclose any harmful effects on the health of the school children who have been medically examined from year to year, nor have any other deleterious effects been noted. Similar favorable results have been reported from a number of other communities in the country, where the supplies have been fluoridated for periods of three to six years. Accordingly, the Department in January, 1951, adopted a policy of recommending the fluoridation of public water supplies when suitable equipment was to be provided and when the treatment process was to be under adequate control. Administrative procedures have been developed for the guidance of local water-supply officials.

Most water-treatment processes remove undesirable substances or organisms from water. However, an exception is the addition of lime to water deficient in mineral content, to make the water less corrosive. In the same way, a fluoride compound is added to a public water supply to compensate for the deficiencies in natural fluoride content of the water, which deficiency cannot be met by the normal diet.

Experience has indicated that water fluoridation is a sound public-health practice, which achieves widespread benefits by action taken on a municipal level. So far, the supplies at Newburgh, New Rochelle, Olean and Westfield, N. Y., are being treated and equipment has been approved for the fluoridation of the supplies for Rochester, Schenectady, Troy, Gloversville, Hudson, Hoosick Falls and the Carle Place Water District. Plans are in preparation for equipment at Buffalo, Poughkeepsie and Amsterdam, N. Y.

Conclusion

The operation of public water supplies so as to secure consistently satisfactory results in the most economical manner presents a challenge to both the designing engineer and the water-works operator. Unfortunately, designing engineers have little opportunity, subsequent to the completion of water-works improvements, to make alterations and changes in the light of operating experience. On the other hand, keen observation of pertinent details by operators has been the basis of economical improvements to the performance of water works. It is hoped that the examples cited above will stimulate interest in this fruitful field.

ESTABLISHMENT OF A NEW WATER SUPPLY AT ESSEX, MASSACHUSETTS

BY JOSEPH N. FARNHAM, JR.*

[*Read February 14, 1952.*]

The town of Essex is approximately 30 miles north of Boston and is about half-way between Beverly and Gloucester. We have a population of 1,800, which is increased in the summer by approximately 300 people, most of whom have summer places at Conomo Point.

Essex is best noted for its clams, that have been distributed to restaurants throughout New England, and also for its shipbuilding. Boat yards have been situated along our river since the early 1600's. Records show that more than 3,200 wooden craft have been built in that time. Probably the best known of Essex-built ships is the recently lost "Gertrude L. Thebaud," which competed against the "Bluenose" in the last of the International Fishermen's Races in 1938.

The summer-resort area of Conomo Point, that I mentioned before, is named in honor of Masconomo, an Indian chief, who at one time owned all the region about this section of the river. It is one of the oldest settlements of summer residents on the North Shore.

Most of the people in Essex are natives of Essex. They have lived here all their lives, as did most of their fathers, etc. It is very hard to change the ways of people that do the same thing day-in and day-out. Most of them would go out of town to do shopping only and then return. Now I am not criticizing the people of Essex, but just explaining their ways, so that you might understand what a project it was to get a water system. I really like Essex and its inhabitants, and it seems to offer a challenge in that when you finally get them to your way of thinking, you really have accomplished something.

Many times the citizens of Essex have voted down the chance to have a water system. They were satisfied with their wells (what few good ones there were), with a spring, and with a town pump.

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I lived in South Essex, where good wells were very scarce, but we had the town pump and many times I carried buckets of water from that. The well at our house was very brackish and salty, as were most of them, so that water for drinking at least had to be carried. Later I carried water from the spring, as did almost everyone else.

I could find no record of this fact, but many of the older folks have told me that in 1907 the city of Gloucester wanted to take water from Chebacco Lake, which is in Essex, and for this right they would run their mains down through our Main St. to Gloucester and leave a tee and gate valve at every street they passed, so that Essex could connect one to these as they saw fit. The objections were that there would be a great deal of land damage, roads would be torn up, and mostly that it would eliminate the boating and swimming at the lake.

The town lost its first chance to have a water supply.

In 1915, the summer people at Conomo Point were ahead of the townspeople in respect to having a public supply. A bill had been passed by the Legislature providing that a water system could be operated at Conomo Point. Windmills were used to pump the water from the wells through the pipes to the camps. In 1922 the Gloucester Water Department connected a summer line to the resort at Conomo Point. The people of Conomo had contributed to buying a 3-inch pipe-line, whereby they had a water system long before the town itself had one. Essex paid the Gloucester Water Department $900 a year, for which they were entitled to approximately 3½ mil gal for the season.

In 1930 there was an article in the warrant to see if the town would appoint a committee to confer with the city government of Gloucester in regard to supplying Essex with water. The committee found that Gloucester needed more water but was indisposed to come to Chebacco Lake for it. They stated the possible cost of constructing water lines from their existing line at West Gloucester to Essex Center, but with no immediate hope of being able to supply Essex because of an inadequate supply of their own.

Again in 1934 the town tried to have a water system. At the annual town meeting the article was postponed until a special meeting in April of the same year. At that time an engineering firm in Boston

sent down a representative, who presented the people with a plan. The town voted $350 for the purpose of test wells. They also voted for a bill to be presented to the Legislature, giving Essex the authority to have a water system.

In October of 1935 a special town meeting was called, after everything including plans and prices was figured out, but again it was voted down. It was estimated that at that time the system could be put in for $162,000. This figure was for only 7 miles of pipe.

It really appeared that Essex was not to have a water system.

Then one day a new doctor moved into town. His name was Dr. John Pallotta. He readily came to know the conditions of wells in the town, and one evening in 1943 he invited a few citizens to his house and from this meeting a Chamber of Commerce was organized. There were 9 people there and I was one of them. This little gathering was to be the start of the present water system.

At that time we were not just interested in water but in the advancement of Essex. Clams were being dug faster than they could produce and wooden shipbuilding was declining. We felt that something had to be done to invite people and also possibly some small businesses to Essex. We believed that water had been a great drawback.

In the warrant of the town meeting in March of 1945 the Chamber of Commerce had put in an article, which resulted in the granting of authority to the Selectmen to appoint a Post-War Planning Committee. I was appointed to the committee and we organized in November of 1945 with 8 members. At that time we discovered that Federal funds were available for the purpose of making surveys for community projects. The funds were procured and acceptance of them was voted in the annual meeting of March, 1946. We were given $9,700 by the Federal government for a complete engineering survey for a town-wide water system. The condition of this $9,700 grant was that if the town did not accept the project, they would not have to return the money and, if the project was accepted, the money was to be returned, which it was.

The first step was to engage an engineering firm to carry out the details of the survey. During April of 1946 representatives of four Boston firms were interviewed by the Selectmen and the members of the Planning Committee.

After due discussion the firm of Hayden, Harding & Buchanan was chosen. The engineers went to work promptly and the field survey was well along by mid-summer.

The final report was completed in October of 1946. A thousand abridged copies of the report were furnished the town by the engineers and a copy was sent to each family in Essex. Six detailed copies of the report were delivered to the Selectmen. The detailed reports included a set of 29 drawings, showing exactly where the pipe would be laid if the system was installed.

In 1947, as a result of this report, the town voted to supply itself with water under the terms of Chapter 251 of the Acts of 1934, which chapter the town had accepted shortly after its passage. Under section 5 of that act, the town was authorized to borrow $150,000 beyond its debt limit, which had been established at $192,000; hence the town was authorized to borrow a total of $342,000. For the purpose of installing the system, the town appropriated from its Post-War Rehabilitation Fund $20,000 and from free cash in the treasury an additional $13,000. At that time, it appeared that the two cash items, totaling $33,000, and $300,000 to be borrowed would be sufficient to complete the work as planned and laid out by the engineers. Notes were issued for $300,000.

The fight, I thought, was over. We were all pleased with the vote and we had certainly put in a great deal of time and effort to convince the people that they needed a water system. We had done such a thorough job that only 69 voters had voted against the project. It was voted on ballots on March 18, 1947, and the polls were open from 2 P.M. to 8 P.M.

But the fight had only begun. We had gone from the frying-pan into the fire.

Shortage of steel to be used in the construction of the standpipe, shortage of some of the other materials to be used in the pipeline, and the necessity of repeal by the Legislature of an old act, which authorized the town to furnish water to the Conomo Point area, all contributed to delay in the commencement of the work. This delay cost us an additional $36,034 in the price rise of pipe alone.

Because of the delay there would be in the delivery of steel for the tank, it was necessary to make new specifications for a cement

tank and receive new bids. The cost of the new tank was $6,000 more than that of the steel tank.

On August 15, 1947, the gravel-packed well was started and on October 7, 1949, the last house service under the contract was finished.

During the period of construction problems were many. The people at first were told that if their house was within 50 ft of the town line, they would not have to pay to be connected with water. After 103 such connections had been made, Henry Long of the Massachusetts Department of Taxation informed us that it was illegal to use town funds on private property. This had to be explained to the people.

The original estimate on the amount of ledge in our streets was 5 times less than what we encountered. Instead of $8,000 for rock removal it was nearly $40,000.

The biggest problem was in May of 1949, when we were informed by the engineers that there was not enough money to finish the system. There was not much time to explain it to the people, but an additional $150,000 was needed.

The time for filing bills in the Legislature had expired, but the bill was admitted by the committees on rules in the House of Representatives and the Senate, such admission having been authorized by these committees only because of the extreme emergency which existed. On June first, after a more or less extensive hearing, the bill was favorably reported by a joint legislative committee on municipal finance, and on June 13, under suspension of the rules, the Senate passed the bill to be engrossed, similar action under suspension of the rules having been taken previously by the House of Representatives. Then on July 6, 1939, there was another special town meeting, at which the people voted to accept chapter 433 of the acts of 1949, whereby an additional appropriation was made.

From here on the greatest problem was to get our roads back in condition which cost an additional $37,000 over the original estimate. The cost of installing services was greater than the original figures, because of the fact that only 265 takers had been expected to take water and we finished with 404.

As previously stated, the last service was completed October 7, 1949. On Sept. 27, 1949, I was appointed Superintendent of our Water Department.

In order to present a true picture of the financial situation, the following figures are given: The original estimate on the project was $330,000.00 After all the extra borrowing we had $495,496.00 to spend. The system cost us $489,261.11, leaving a balance of $6,234.89, of which $5,000 was used to help pay off the notes the first year.

There are laid in our streets 11.6 miles of Johns-Manville cement-asbestos pipe, made up of 20,896 ft of 12-inch pipe, 18,041 ft of 10-inch pipe and 22,716 ft of 8-inch pipe. There are at the present time 453 house services plus 120 summer services. We have in town 113 hydrants on the system. The pressure on these hydrants varies according to their location from 72 lb to 102 lb.

On Aug. 4, 1949, Mr. Arthur S. Wright, of the New England Fire Insurance Rating Association, conducted a series of tests on the hydrants. Requirements are that a hydrant shall yield at least 500 gal per min with a residual pressure of not less than 20 lb. The results of the tests were as follows:

Hydrant No. 1	
Static pressure	83 lb
Residual	67 "
1,160 gal per min	
Hydrant No. 2	
Static pressure	73 lb
Residual	61 "
1,080 gal per min	
Hydrant No. 3	
Static pressure	84 lb
Residual	81 "
1,080 gal per min	

Mr. Wright was well pleased with the results of this test. He expressed the fact that Essex had a well- and amply-designed system, and that many towns make the mistake of putting in small mains and have to enlarge them later.

We have one gravel-packed well which is 38 ft deep. The pump and station are located right over the well. The pump is a multi-stage, deep-well turbine type, with a capacity of 250 gpm. The pump is driven by a 15-hp, 3-phase, 60-cycle electric motor. There is also a 4-cylinder, Continental, auxiliary gasoline engine, connected to the

pump with a right angle drive, that can be used in case of electric power failure. The pump is capable of pumping 360,000 gal a day. At the present time we are pumping approximately 82,000 gal per day.

The pumping station is a building 22 ft by 14 ft. It is a one-story building with yellow brick walls outside and yellow glazed tile inside. It has a distinctly modern appearance with glass-block windows, in which are set small square panels that open for ventilation. There are three rooms. The main room contains the electric control board with its various master switches, a Builders Flow Meter to give daily record of water pumped, and a gauge to show the height of water in our standpipe. Nearby are the motors for driving the pump. Also in the station are a heater room, containing an oil-fired, thermostatically controlled, warm-air heater, and a work room, containing a bench and drawers, where I keep and repair meters. The building is built on a concrete foundation.

Our storage tank, which is located on a hill approximately 190 ft above sea level, has a capacity of 564,000 gal. The tank is made of concrete, reinforced throughout with steel. It has an inside diameter of 60 ft. The walls are 15 in. thick and the tank is 27 ft high.

Besides our 11.6 miles of main pipe we have approximately 5 miles of galvanized surface lines, ranging from 1 in. to 3 in. in size. These lines pass through many wooded sections and have fire valves installed in them, whereby the Fire Department may attach hose.

Except for the summer services the system is all metered.

The well and pumping-station contractor was D. L. Maher Co. of Cambridge. F. E. Daddario of Boston was the contractor for the standpipe and the Capaldi Bros. Construction Co. of Rhode Island installed the mains.

Although there was talk of graduating from wells and springs to a town water system for years, off and on, action was precipitated by the board of selectmen and the goal was finally reached, at least for 80% of the Essex residents, who will no longer have to worry about their wells' drying up in mid-summer.

THE EVER LENGTHENING SHADOW

BY RALPH M. BINNEY*

[*Read March 20, 1952.*]

My subject today deals with taxes, something we are all particularly conscious of today—the big bite—since we had to file our Federal tax return on or before March 15—and many of us will be reminded of the subject again before April 15, when our State taxes have to be paid.

I am going to deal largely with Federal expenditures and the taxes that are imposed to support this tremendous national spending. I hope, however, to show you how these taxes affect every wage-earner and every household in New England. At the same time, I shall try to point out to you various ways that I think government expenditures can be reduced, so that the nation can operate on a balanced budget and we can prevent the purchasing power of our wages from being further reduced.

Federal expenditures for the fiscal year ending June 30, 1952, are estimated at $71.6 billion. President Truman has presented a budget for fiscal 1953 of $85.4 billion. This means that by the end of June next year the Federal Government will have spent about $400 billion since the end of World War II. This amount exceeds by $233 billion the total outlay by the Federal Government for the 151 years from 1789 to 1940, which period included the War of 1812, the Civil, the Mexican and Spanish-American Wars, and World War I.

The amount of money spent by the Federal Government is so staggering that most persons have no conception of its magnitude and, in consequence, have not been too much concerned about national fiscal affairs. The figures carry more meaning when it is pointed out that for the calendar year 1951, Federal expenditures were nearly equivalent to all the wages and salaries of the more than 15 million or so workers employed in all the factories and mines of the country. *In 1939,* Federal expenditures represented but *60% of the wages* and salaries of the foregoing groups, *and in 1929 only about 20%.* If

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state and local units are included, *total government expenditures in 1951 were equal to about 57% of total wages and salaries of all persons—from the lowest-paid worker to the highest-paid executive—engaged in gainful non-Government pursuits.*

Based upon past experience of other countries, this high proportion of taxation for governmental purposes is perilous, because of the strain imposed upon the economy and the living standards of the people.

The extent of the drain by government of the people's income is *graphically presented on the accompanying map* (Figure 1). In 1929,

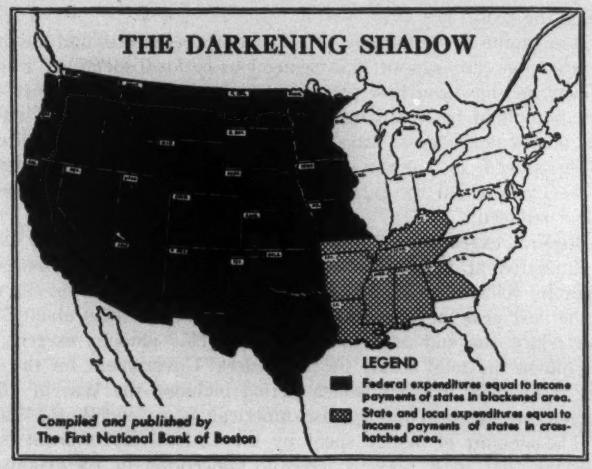
THE DARKENING SHADOW
LEGEND
Federal expenditures equal to income payments of states in blackened area.
State and local expenditures equal to income payments of states in cross-hatched area.
Compiled and published by
The First National Bank of Boston

FIG. 1.

Federal expenditures were less than two thirds of the total income payments to the inhabitants of California. In 1938, Federal expenditures were equal to the income payments of the eleven Pacific and Mountain states. For the fiscal year ending June 30, 1952, it is estimated that Federal expenditures will take the equivalent of the aggregate income payments of the Pacific and Mountain states and, in addition, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma,

Texas, Minnesota, Iowa, and nearly three-fourths of Missouri. This is shown by the blackened area on the accompanying map. If total state and local expenditures are added, the area would be extended to include the remaining portion of Missouri, plus Arkansas, Louisiana, Kentucky, Tennessee, Mississippi, Alabama, and two-thirds of Georgia, as is shown by the cross-hatched section of the map. In other words, total governmental expenditures for the current fiscal year will take an amount equal to all of the income payments to individuals of states with a land area that covers nearly four-fifths of the country and has an aggregate population of about 62 million persons and more than 22 million workers.

In order to meet its huge running expenses, the Government must collect revenue from all income groups in every nook and corner of the country, and every worker is compelled to spend an increasing amount of time working for the Government. In 1939, for instance, a married man with an income of $2,500 a year was exempt from Federal taxation and was able to keep all his earnings. In the current fiscal year, however, he is compelled to work 22 days to pay his Federal income tax. A married person with an income of $5,000 a year would work 34 days for the Federal Government; one with $10,000, 43 days. A person in the $100,000 class works nearly ½ of his time for the Government, or more than three times as long as a person with a $5,000 income.

But aside from the injustice and the impairment to personal incentives involved in looting the rich, the revenue that can be obtained from this source is comparatively small. *If all personal taxable income of $25,000 a year and over were confiscated by the Government, the amount would be sufficient to pay the current running expenses of the Federal Government for only about 10 days.* It stands to reason, therefore, that as our tax burdens expand, those in the lower income groups not only will have to spend an increasing number of days working for the Government, but also will be forced to bear the bulk of additional taxes.

In Great Britain, with a shriveling of income of the wealthy, the tax burden is being shifted to the lower income groups. Data compiled by the British Financial Secretary in a report to Parliament show that total taxes of those in the income group below £1,000

($2,800) a year increased by 615% from 1938 to 1949, while those receiving £1,000 and over showed a gain of 170%.

Government expenditures in this country constitute nearly as large a proportion of national income as in Great Britain, which has for many years been dependent upon us for substantial financial aid. *The British experience should be a dire warning to us, as we are traveling down the same road to insolvency and we must make a detour before it is too late.* No other nation is coming to our rescue and bailing us out if we get in financial difficulties.

This country must, of course, spend whatever is necessary to bolster our national defense. But while we are spending staggering amounts for military purposes as a protection against aggression, the Administration is undermining our financial segment, the cornerstone of our nation's security, by condoningg waste and extravagance that, in the aggregate, may approximate $15 billion annually. Furthermore, there is no apparent official concern over our financial plight, as is evidenced by the fact that pressure groups within the Government itself are busily drawing up blueprints and propagandizing for all sorts of projects that not only have no connection with national defense, but also have a Utopian tinge. It is to be hoped that the taxpayers of the country will be aroused from their lethargy and, while there is still time, realize that they are the victims of "squandermaniacal" public servants, who are "selling them down the river". The crucial financial situation calls for a united front by those who pay the bills.

In view of the staggering amounts spent for defense, it would be reasonable to expect that serious efforts would be made to cut non-military expenditures. But such is not the case. The trend of non-military expenditures has been definitely upward and it is estimated that these expenditures for the current fiscal year are about 300% above 1939. We are told that the budget is "tight"; yet we find that the number of civilian employees on the Federal payroll is steadily mounting and since 1939 has shown a gain of 185%, or 10 times the rate of increase in the general population during this period. The mushroom growth of Government is placing an onerous burden on the backs of taxpayers. Based upon estimated Federal expenditures for the next fiscal year, New England's share would be

over $5.5 billion, or nearly equal to the total income of this region in 1939. This is a serious drain on funds sorely needed here for the maintenance of a healthy and vigorous economy. The same can be said for other regions of the country.

The champion spenders are not concerned about the staggering outlay of public funds, but rather contend that this makes for an expanding economy and promotes general welfare. Obviously, neither one of these objectives can be attained in this way. On the contrary, unsound fiscal policies, with claims on national income increasing in snowball fashion, undermine the economy, stifle initiative, discourage risk taking, and cast a dark shadow over the future.

Looking over the "tight" budget for 1953, which is supposed to be geared to defense, a reader might get the impression that we were getting ready to defend ourselves against Indians. The Bureau of Indian Affairs, part of the Interior Department, wants to add nearly 4,000 more employees than it has this year. A couple of Indian women testified at the hearings on the appropriation to the effect that "something ought to be done to get rid of these bureaucrats." The Indians don't want 'em; the taxpayers don't want 'em—so why add 4,000 more?

Old-Agencies-Never-Die Dept.: The National Capital Sesquicentennial Commission, which made an abortive attempt to have a sort of World's Fair in Washington in 1950, still has eight employees. In fact, it expects to spend about $97,000 in 1953, three years after the Sesquicentennial, according to the President's budget. This is unquestionably an essential expenditure, since the President has said that everything in the budget is essential. But I can't help wondering how they tie THAT one to national defense.

Nevertheless, we are told that the budget is "tight" and that all items are sacrosanct. Various authorities, liberal as well as conservative, however, contend that a large amount of "fat" could be cut away without impairing the functioning of the Government machine. Estimates on possible reductions in Government costs average around $14 billion. This would be a substantial saving and is equivalent to twice the total of Federal expenditures in 1938. If this amount were distributed among the various states, based upon their contribution to Federal taxes, New England's share would be over $100 million.

The findings of the Hoover Commission revealed shocking waste, overlapping, duplication, and gross inefficiency of the multitudinous Government agencies and commissions and of antiquated and slothful methods of accounting. If any private business had carried on its affairs in as slip-shod a manner, it would have gone broke and been subjected to prosecution for juggling figures. A few illustrations will indicate the slackness that prevails in the Federal Government. In order to avoid having a surplus, most agencies indulge in a splurge of spending at the end of the fiscal year. The cost of paper work exceeds the cost of individual items that go to make up one-half of the 3 million purchase orders each year. There are, on the average, about 3.6 typewriters to every worker in the Federal Government who uses one. The cost of construction of Federal hospitals is $30,000 per hospital bed, as against $16,000 for private hospitals. Employees in the Veterans' Administration handle on the average only about one-fourth as many insurance policies as are handled per worker in private insurance companies. The importance of a department is usually gauged by the number of persons employed, rather than by the volume of essential work performed, with the consequent inducement to over-staffing.

Classified Federal employees are entitled to 5 1/5 weeks' vacation and three weeks' sick leave each year, or about twice the allowance to the workers in private enterprise.

There are several thousand highly competent employees in the Federal Government and many of them are underpaid. The situation could be substantially improved by upgrading the deserving and cutting down on the labor force. Without entailing any hardship or sacrifice on the part of those employed, this could be brought about by vigorous adherence, whenever possible, to the "no-hiring" policy when vacancies occur and by transferring workers now employed in the less essential Federal services to the needed defense agencies, instead of recruiting help from a tight labor market. More than 500,000 workers leave the Federal service each year for one reason or another. By pooling the available personnel and assigning the workers wherever they could be most effectively utilized, it would be possible in the course of a comparatively short period to bring about a substantial reduction in the number of Governmental workers with-

out sacrifice of essential services. Since Federal payrolls of civilian workers exceed $7 billion, it is obvious that the taxpayers' bill could be considerably reduced under such a reorganization plan. Similar action should be taken in state and local governments.

But all the waste cannot be laid to Federal employees. For nearly a decade and a half the dominating philosophy of this country has been to turn to the Government for hand-outs of one kind or another and this attitude has been encouraged by the Administration in power. As a consequence, all classes of pressure groups from every section of the country have made shameful raids on the Treasury to get their share of the "spoils" apparently on the theory that they are getting something for nothing. But this money is collected from the taxpayers in all sections and then portions are distributed back in the form of grants to the states, with strings attached. The heavy levy of Federal taxes can more clearly be seen on a regional basis. Based upon the Administration's tax program for the next fiscal year, it is estimated that the total levy for the New England states, which have only about 6% of the population of the U.S., will be over $4.6 billion, or nearly as much as was paid by all the people of the country in 1940. The tax per household in New England averages around $1,680 and this compares with $1,578 per household for the country as a whole.

Federal expenditures within a given region are not in the same proportion as revenues received from that region. In some areas of the South and West, Federal expenditures exceed receipts. In New England, however, over the years there has been a heavy net outflow. Based upon a study by the Federal Reserve Bank of Boston, the direct net Treasury transfers from New England for the period 1929-1949 aggregated more than $11 billion. Some authorities in this section have contended that New England should make vigorous efforts to obtain a larger share of Federal funds. But this would invite sectional rivalry and merely aggravate the plunder on the Treasury at a time when Federal financies are in a critical stage. Instead, for the duration, all sections should agree to a moratorium on all forms of subsidies and grants.

Recently, all of you have filed your withholding forms along with your Federal income tax and you realize how much of your earnings have been taken by the National Government. Do you realize, how-

ever, that most people pay out more in *hidden* Federal taxes than they pay in direct taxes on their income? The personal income tax is the one tax almost everyone has in mind when they complain of the heavy burden of taxation. But how many $5,000- to $7,500-a year people are aware of the fact that over 35% of their income is taken away by the government?

Do you realize that, despite soaring food costs, the Massachusetts family with an income of $5,000 pays more in Federal taxes than in grocery bills? According to the figures just compiled by the National Association of Manufacturers, the average Federal tax bill of the $5,000 family is $1,300, against a food bill of $1,100. The food bill takes 26 cents out of every income dollar, but the tax bill takes even more.

There is only one way to lighten this burden of taxes on the low- and middle-income groups and that is by a reduction in government expenditures.

President Truman has indicated that his $85.4 billion budget is a "tight" budget and he has challenged anyone to show him where it can be cut.

I think you know just as well as I do that any budget of that size—it is bigger and heavier than the Manhattan telephone book—made up of the requests of so many bureaus and departments, can certainly stand some paring if it is carefully studied.

The Chamber of Commerce of the U.S. and several other reliable organizations estimate that from $10 to $15 billions can be taken out of the budget as submitted, without impairing any essential service. The Chamber of Commerce would trim $14.4 billion from the recommended budget and hold government spending to the $71 billion level of last year. This can be accomplished in this way:

Finance, Commerce and Industry—Cut $475 million by eliminating proposed new legislation for economic controls and an expansion of operations under the Defense Production Act.

Natural Resources—Cut $225 million by holding work on several new long-range non-defense projects to their present levels. These would not affect atomic energy development, defense or major emergency programs under this heading.

Agriculture—Cut $332 million by reducing conservation and development payments and making smaller reductions in such programs as rural electrification, crop insurance, and the financing of farm ownership. These cuts would still leave agriculture expenditures about 76% higher than last year.

Housing and Community Development—Cut $542 million by eliminating a proposed $300 million expansion of federal civilian-defense construction grants, because it is a State function, by reducing defense-housing expenditures to fiscal 1952 levels, and by discontinuing the public housing program, in a time of credit restrictions and alleged shortage, thus preventing the issuance of up to $750 million of tax-exempt housing bonds.

Education and General Research—Save $355 miliion by eliminating proposed expenditures for federal intervention in State education programs and for subsidies to college students. These programs have not been approved by Congress and the proposed 1953 expenditures are more than five times as high as last year's.

Social Security, Welfare and Health—Cut $780 million by reducing federal health expenditures and public assistance grants to 1948 levels. These welfare and health programs have grown phenominally in the past five years. This cut proposed a reduction to the relatively high levels of 1948. It also proposed a reduction of public assistance grants, in a time of high prosperity and expanding social-security coverage, to 1948 levels as a first step in returning this function to the State, where it belongs.

Veterans Programs—Cut $135 million by postponing construction of three new hospitals, not yet started and admittedly not needed, and adopting Hoover Commission recommendations for the reorganization of the Veterans Administration. Such improvements would increase the efficiency of veterans insurance and other operations and provide better service at less cost.

General Government and Reserve—Save $225 million by holding the reserve for contingencies to the 1952 level and requiring agencies under "General Government" to absorb an aggregate 10% cut.

International Security and Foreign Relations—Cut $5,844,000,000 by holding expenditures for this purpose to $5,000,000,000. The size of the budget requires a choice among expenditures, if

the budget is to be balanced. The $10.5 billion figure, proposed as foreign aid, is nearly twice the amount federal, state and local governments spend on public school education in the United States. Of the $10.5 billion of foreign aid, $3.3 billion would be spent from funds provided by new legislation not yet approved by Congress. Holding this item down to $5 billion would still allow substantially more spending than last year.

Military Services

1953 Budget,	$51,163,000,000	(1952: $39,753,000,000)
Reduced to	45,632,000,000	(1951: $20,462,000,000)
Saving:	$ 5,531,000,000	

It is proposed that the military services themselves could withhold spending in this amount without reducing the level of national defense in any way. Investigation of Congressional committees has indicated that inefficient procurement practice by all services involve a waste of $5 billion or more, which could be avoided. Tightening up on excessive expenditures for operations and maintenance categories, and for land acquisition and construction could probably save from half a billion to a billion dollars a year. It is essential that the services themselves contribute to the national economic security for the indefinite period of the "cold war" by making certain that each dollar spent buys a dollar's worth of defense.

The cuts proposed add up to $14,444,000,000—enough to bring the proposed budget down to the level of $71 billion of estimated revenue. Actually, the $14.4 billion does not represent a net cut below current spending, because fiscal 1952 spending is estimated at $71 billion, precisely the amount of estimated 1953 revenue.

The only way for us to avoid disaster is for the taxpayers to insist upon the elimination of waste and extravagance at all levels of Government—Federal, State and local. We have reached a stage where these combined governmental claims on our income are constantly mounting, while productivity—which is the only real source of national income and wealth—has increased over the years at an annual rate of only about 3%. As a matter of fact, since the start of hostilities in Korea, productivity per worker has shown no gain. This is important to all of us living in the New England area and

we must do everything we can to control the expenditure of our own income in the way we see fit, and not have a bureaucratic government in Washington tell us how we are going to spend it and what for, and specify the standards to be met. I am sure the people of New England would much prefer to finance their own activities according to their own requirements and not have some social planners work out their programs and dole out their own tax money as they might see fit.

If the President's budget is accepted, there will be a deficit of about $15 billion, as I have pointed out to you. This huge deficit *alone* is more than the total amount of taxes collected by the 48 states last year for the support of all state, county and municipal governments combined.

To my mind, this budget—as now proposed—is bursting at the seams with excessive and wasteful bureaucratic spending practices. It is up to Congress to apply the axe to these bloated spending requests. This will never be done unless aroused citizens—who are tired of paying through the nose—become vocal and insist that expenditures be cut to the bone. We have neither time nor money for experiments or frills during a period when we are fighting for the survival of our way of life.

We must stop that ominous shadow from spreading now or we shall all be living under complete federal control.

OPERATION OF THE DENNIS WATER DISTRICT

BY GORDON A. BARKER*

[*Read March 20, 1952.*]

The town of Dennis, Massachusetts, on sunny Cape Cod, is just 80 miles from Boston. Located in Mid-Cape, halfway between Hyannis and Chatham, it covers an area of 20 square miles. It is bounded on the south by Nantucket Sound, on the north by Cape Cod Bay, on the west by the town of Yarmouth, separated by Bass River, and on the east by Harwich and Brewster. Within the town are located five villages, separate among themselves, with their own churches, post-offices and stores. The town has a normal population of approximately 2,500, which increases to 12,000-15,000 during the summer months.

The Ezra H. Baker Elementary School, with its new addition of classrooms and combination auditorium-gymnasium, is centrally located in South Dennis, and pupils are transported in modern buses.

The Town Office, with offices for Selectmen, Board of Assessors, Public Welfare, Town Treasurer, and Board of Registration, is also located centrally in a new building completed in 1950. Two fire stations, one on the north shore and one on the south shore, put all residences within easy fire protection, there being three up-to-date pieces of fire apparatus in the North Station and five pieces in the South Station, with a combination emergency-ambulance truck on the south side.

This is all to present a picture of the town of Dennis, so that you may visualize what our problems are in comparison to a town that is confined to a small area. There are about 125 miles of town-accepted streets within the town of Dennis, with as many more private streets and ways.

In 1951, the assessed valuation and bonded debt were as follows:

Assessed valuation of the town	$11,188,208
Assessed valuation of the district	$8,090,555
Bonded debt of the town	$290,000
Bonded debt of the district	$538,200

*Superintendent, Dennis Water District, South Dennis, Mass.

At the annual town meeting of the town of Dennis on March 7, 1944, the following Article appeared in the warrant and was accepted:

> "To see if the Town will vote to instruct the Selectmen to appoint a committee of five to investigate and report at the next Annual Town Meeting as to the cost of building a water system and recommend the location of a Water District on the south side of the Town of Dennis, and appropriate $100 to defray the expense of the committee."

The committee appointed consisted of Benjamin P. Chase, O. Thomas Murray, James L. Speirs, Albert H. Crowell, William C. Kelley, Charles Johnson and Nathan Crowell.

The first meeting of the committee was held on March 19, 1944, for organizational purposes. At the second meeting, Mr. Paul Howard of Whitman & Howard, Engineers, was present and was authorized to investigate and make proposals for a water system or systems within the town.

At a later meeting, after a complete survey of the town had been made and the results of all investigations and pertinent material had been assembled, Mr. Howard presented the committee with three complete proposed water systems for their choice:

1. A system covering the entire town.
2. A system covering the South Side only.
3. A system covering the North Side only.

Also prepared was a very comprehensive study of available water supply, materials necessary and available, costs, methods of financing, organization and benefits of lower insurance rates, proposed water rates, and all other details necessary for the proper function of a water system.

The committee filed with the State Legislature the necessary bills, whereby the voters of the town could create a district or districts, whichever they deemed advisable. During the winter of 1945 a Special Act, Chapter 277 of the Acts of 1945, was passed by the Legislature, allowing the inhabitants of Dennis to set up a Water District within the town. During June and July of that same year the committee held many public meetings in each of the five villages of the town, at which time information was given by the committee to all interested people of the town.

In August, a Special Town Meeting was held in conformity with

the Act and it was voted 139 to 13 to accept the provisions of the Act, and to borrow and appropriate $500,000 to construct a public water system, establishing the Dennis Water District and covering all villages of the town. A Board of Water Commissioners was appointed, which met and organized with O. Thomas Murray, Chairman. Other members were James L. Speirs and Nathan Crowell. Joshua Crowell was chosen Clerk and Treasurer. I have been indeed fortunate to have had the same Board of Commissioners, Clerk and Treasurer during the past six years, and complete coöperation and harmony have always existed. Whitman & Howard were selected as the Engineers. Materials were advertised for and bids received for the laying of the mains, construction of the pumping station and tanks, and the installation of the house services. All contracts were signed before January 1, 1946.

The test wells were driven in September and October of 1945, and after exhaustive test proved satisfactory as to quantity and quality of water. The following is quoted from a report of the Massachusetts Department of Public Health, which approved the water supply.

> "The results of the analysis show that the water pumped throughout the test continued to be clear, colorless, low in organic matter, very low in iron and free from manganese. Field test showed that the amount of carbon dioxide gas present in the water increased during the test, but at the end of the test was not such as would be likely to result in active corrosion of metallic pipes."

The five gravel-packed wells were dug during the winter and spring of 1945-1946 to a depth of 40-45 ft below ground level. During test, each well produced approximately 260 gal of water, or a total for the five wells of 1,300 gal per minute. The wells are of 8-inch, extra heavy, wrought-iron pipe, with a 10-foot Everdur screen at the bottom of each well, resting on a 24-inch concrete slab. There is an area of 42 in. of washed gravel around each well.

No blasting was necessary during the digging of the wells and only in one well was rock encountered. This was broken into pieces and removed without difficulty. Up to the present time, the wells never have been drawn to capacity, there being an average of 22 to 25 ft of water in each well at static level. Water levels are taken Monday of each week and records kept for future reference. The

five wells are connected to a common 12-inch suction line, which runs for 800 ft directly into the pumping station. Each well is separately gated, so that it may be worked on without affecting the remainder of the well field.

The laying of the Class 150, cement-lined, cast-iron water mains started about April 1, 1946, after delays due to coal and steel strikes. Two shovels were in operation in different sections of the town and proceeded without delay. All digging on the south side was in sand, while on the north side, clay, rock and hardpan, as well as sand, were encountered. On both sides ground water was present and it was necessary to employ a well-point system before the mains could be laid in some areas. All trenches were to a depth of 4½ ft. All side streets were independently gated and this system has proved very convenient. All hydrants were independently gated and placed according to rule and custom, so as to give maximum fire protection, and so that buildings would be within 500 ft, in order to obtain the maximum reduction in insurance rates. All hydrants are of 5-inch valve opening, with one 4½-inch steamer connection and two 2½-inch hose connections.

A sufficient number of gate valves has been installed so that any section may be shut off readily without interfering with other sections, villages, or areas within the villages.

By April, 1947, or one year following the start of construction, the standpipe in East Dennis had been erected and made ready for use; 30 miles of mains had been completed, chlorinated and tested, and a good portion of the 550 house services had been laid, so that meters could be installed by the Water District and water furnished for house consumption, as well as fire protection. Cement-lined, wrought-iron service pipe was used throughout, with corporation and copper gooseneck at the main, and a T.H. curb cock at the property line with a cast-iron No. 1 curb box, and a Y valve in the cellar before the meter at the water taker's property.

In the course of the installation of the water mains on streets and ways, one river crossing was encountered. The distance covered by the river crossing consisted of about 50 ft of actual river bed and, on each side, an additional 100 ft of low, mucky bog land. Cast-iron pipe was used with mechanical joints. When the river bed had been

temporarily blocked, the stream diverted and the trench dug, the three lengths of pipe were connected and lowered to the river bed by cranes, and a diver was employed to go down with the pipe, to see that it was in its proper place. When the pipe on both sides had been added and connected, and the diver had tightened all joints, a water-pressure test was given and found satisfactory. An engineer's rod was given to the diver to place on the pipe when it was in place, and records were made from a boat, to determine the exact depth of the pipe and to plot its contour. Valves are located on each side of the river crossing, so that it may be shut off for repair, and a hydrant is located on each side, so that fire hose may be used from hydrant to hydrant in an emergency.

The money borrowed was obtained at a rate of 1¾% for 30 years, payable $18,000 per year, plus interest semi-annually. Since the original borrowing, there have been five additional bond issues, amounting to $173,500 borrowed at different times for periods up to 15 years, and further note issues of five years or less for $20,900. The total additional money spent for extensions amounts to $194,000. These additions have cost us an average of $4.00 per foot. In the short period of time it has been operating, the District has been unable to accumulate a large surplus to finance cost of extensions and still maintain a reasonable tax rate. It is necessary, therefore, that all extensions be financed by the borrowing of funds.

The pumping station is built close to the wells and is constructed of reinforced-concrete poured walls below ground level, and stuccoed cinder blocks above ground level. The roof is of wood with fire-resistant shingles. The pump room, located 12 ft below ground level, is 20 ft by 24 ft. Here is located all the necessary equipment for the pumping of water from the well field to the distribution system and storage tanks.

There is one 200-gpm, 3-stage centrifugal pump, connected to a 25-hp electric motor; one 500-gpm, 2-stage centrifugal pump, connected to a 60-hp electric motor, and one 500-gpm single-stage centrifugal pump, connected to a 6-cylinder, Chrysler, industrial gasoline engine, to provide the necessary stand-by unit in case of power failure.

A vacuum pump, connected to an electric motor, and a duplicate,

connected to a Wisconsin gasoline engine, keep the pumps and vacuum tank primed, and are so wired to the electrical system that, should for any reason the pumps lose their vacuum, the large pumping motors will cut out.

The controls for the pumps operate off the pressure line and, when the pressure drops to a pre-determined point, which is adjustable, a pilot light comes on and, working wth mercury switches, starts the pumps. They continue to run until the pressure in the system has reached a point which has been pre-determined as the pressure at which both tanks will be filled. It has been the experience of the Superintendent that the tanks can be filled to within one foot of the overflow level. Electricity is fed to the pumping station on a 2,300-volt line, direct from the sub-station of the electric company to a transformer crib, located on Water District property, and is transformed to 440 volts for pump operation and 110 volts for lighting and other domestic purposes.

Water is discharged from the pumping station by two discharge lines, one 8-inch and one 6-inch, all properly gated, so that water may be pumped by one or all pumps to the north side, by one or all pumps to the south side, or by one pump to the north side and the other to the south side.

The water is pumped directly into the distribution system and storage tanks, of which there are two. The elevated tank, with a capacity of 200,000 gal, is located on the south side of the town, in West Dennis, 2 miles from the pumping station, on a ground elevation 27 ft above sea level. This tank is 171 ft tall and overflows at 198 ft above sea level.

The standpipe, with a capacity of 400,000 gal, is on the north side of the town, in East Dennis, 5 miles distant in the opposite direction, on a ground elevation 128 ft above sea level. The tank is 70 ft tall. Thus it is evident that both tanks are of the same elevation, in that they overflow at the same point, 198 ft above sea level. This provides a pressure throughout the town of 75-80 lb.

At this point it might be interesting to note that the tanks in our neighboring towns of Harwich and Yarmouth overflow at approximately this same level, so that in an emergency an interconnection between the towns would be possible without any great difference in

pumping head, with due allowance, of course, for friction loss in distance. At the present time we are interconnected with the town of Harwich on the east by a 6-inch main, controlled by two gates at the town line; and it is hoped in the near future to effect a connection with the town of Yarmouth with an 8-inch main. When this is completed, there will be in effect a connection between the distribution systems of Chatham, Harwich, Dennis, Yarmouth, Hyannis, Barnstable, Centerville and Osterville.

Within the pumping station is also located the office for the Water District, where all billing and collections of water rates are done. The Superintendent is responsible for the billing and collection of all water rates and service-connection charges in a district. Bills for payment are assembled and recorded on vouchers and warrants at the office, signed by the Board of Water Commissioners, and turned over to the Treasurer of the District for payment. The Commissioners use this office as a meeting place for their regular meetings.

The office is at ground level, above the pump room. Beside the office is the garage and work shop, which is 35 ft by 27 ft. In this room are located meter storage bins, meter-repair and testing benches, work benches, and garage space for one pick-up truck, together with storage bins for service-installation materials. All house services are installed by employees of the Water District from the main to the cellar of the water taker or meter location designated by the property owner.

I think there is one problem that Superintendents on the Cape would like to wish off on someone, and that is the removal of all summer meters in the fall for storage. In our case this entails the problem of removing approximately 600 meters at the beck and call of plumbers or property owners, the storage of these meters until spring, and then the reinstallation of the meters. It must be remembered that a good share of summer houses and cottages have no cellars. Thus the meter cannot be placed where it will not freeze in winter, unless the property owner invests in a pit on his property, which we encourage to the fullest extent.

Meters are read quarterly in all villages at present, but the time may come when this procedure may have to be staggered by villages, along with the billing. Meters are read for excess consumption once

a year and billings made at that time, along with the quarterly change.

Rates charged for water by the District are:

$24.00 minimum per year for 40,000 gal;
$ .40 per thousand in excess of 40,000 for the next 60,000 gal;
$ .25 per thousand for all water in excess of 100,000 gal.

Property owners are required to pay for the installation of service connections to their property, from the property line or back edge of the sidewalk to the meter location, at the rate of $1.00 per foot for ¾" service, $1.10 for 1" service, $1.40 for 1½" service, and $1.60 for 2" service. The cost of that part of the service in the street is assumed by the District.

All extension work is let out on bid and has been done recently by a local contractor, who is well equipped to lay water mains. He has done a very good job at reasonable prices. In comparison, it is interesting to note that in 1946, under the original contract, 8-inch mains were furnished and laid for $2.03 per foot, while today the cost is $3.22 per foot. It is estimated that to build our system now would cost double the original $500,000.

To bring you up to date on the system, and as a summary for this paper, I shall give you the high points of our Annual Report for 1951.

The total number of metered services installed is now almost 1,250. There are 36 miles of mains, 6 miles having been added since the original construction plan. We are now completing construction of approximately 3 miles of 8- and 6-inch cast-iron mains. It is anticipated that about 200 services will be secured from this extension, in addition to the new services to be added from already existing mains. What the coming Annual District Meeting will unfold may be another story. We have in effect in the District by-laws at present a 6% clause, which acts as sort of a buffer for any splurge. Any extension must show 6% return of the cost of construction before it is installed, and on any developments the 6% must be guaranteed in writing for a 15-year period, with a written attachment against the property on file at the Registry of Deeds.

The pumping station has remained in its original status, with sufficient pumping capacity to take care of the present demand, and we hope of that for many years to come. Water pumped in 1951

amounted to 48,796,000 gal, an increase over last year of 7.94%. The largest daily consumption was 587,000 gal on July 7, 1951. It must be remembered in connection with this figure that we have no industrial buildings and no large hotels. Almost all consumption is for one- or two-family residential structures.

A new storage building, 20 ft by 40 ft, was constructed last April at a cost of $2,000. It provides additional storage for service pipe, service materials, spare hydrants and valves, air compressor and portable pumps.

The rolling stock consists of the following:

1 1950 1-ton truck, pick-up body with side racks for service materials;
1 1947 ¾-ton truck for service-installation crew;
1 portable, 60-foot, Chicago, pneumatic air compressor with all necessary tools;
1 portable Edson diaphragm pump;
1 Sterling centrifugal pump;
1 1,500-watt, portable, Homelite lighting plant, to provide illumination for any emergency night work and light and heat at the pumping station, should power fail.

The truck used by the Superintendent is equipped with a General Electric 2-way radio. We are the only Water Department on the Cape that has a 2-way radio. I am glad to be a pioneer in this line, as I feel it is one of the coming necessities of a water department, whether in a congested or a widely scattered area. The town already has a central Fire and Police Station, equipped with both fire and police radio and manned 24 hours a day. The Fire Department, operating on 31.44 megacycles according to law, can incorporate a water-department vehicle, thus saving a great deal of money for the installation of a permanent station. Of course, a city water department would find it advisable to have its own frequency, operate its own main station, and have all mobile cars under its own jurisdiction.

Those of you who have 2-way radios in your departments would never be without them, I am sure, now that they have proved what a saving in time and property damage they mean, besides the convenience of being in contact with key personnel, service repair or emergency crews.

The radio has proved most satisfactory to us in our small town, in that the Superintendent or operator of the truck is in constant touch

with the office. Under this system the water department can be contacted day or night, at a moment's notice. With a large territory to cover, similar to what we have, personnel can be summoned for any emergency, and it helps to keep the superintendent or personnel in direct touch with what is going on in the fire department.

Many cases could be cited where broken mains or pipes have endangered property or life and, had it not been for the 2-way radio, more serious damage would have occurred. Instead, it was only a matter of minutes before someone was there to take care of the situation.

The personnel of our District consists of a Superintendent, assistant superintendent, office assistant and two year-round employees. In a small department it is necessary that one employee know how and be able to do many jobs. The assistant superintendent, with the two permanent employees, normally in good weather is installing services. In the spring and summer additional help is secured, usually college or high-school boys. There is very little local help available then, as almost everyone has a job working for property owners or contractors, getting places ready for a busy summer season. When local men are looking for work in the winter, the water department work is slack. We plan to do our repair and maintenance work in the fall. Meters are read quarterly by four employees using two trucks, and this work is accomplished in one week. At present we are operating one man short, as the assistant superintendent has been called back into the armed forces. This means additional responsibility for the present three outside employees. The office assistant does no outside work.

During winter months when we have bad weather (snow once in a whlie—I don't know what happened this year, but it seems that all we have done for the past month is shovel out hydrants), the pump room and work shop are painted, and necessary repairs are made to equipment, to put everything in proper shape for a busy summer. Personnel have their two weeks' vacation in the fall.

I think the Superintendent's greatest problem is money, and I don't always mean his salary. Accounts Receivable must be held under strict control, and bills and notices sent. Personal contact and sometimes the filing of liens on property are necessary. This is where

the Superintendent is called those nice names, when he must inform the taker that, unless payment is forthcoming, the water will be shut off. In our District, the amount of $47,981.96 was committed by the Commissioners to the Superintendent for collection for the year 1951. On January 28, 1952, the annual State audit showed on the balance sheet $2,317.30 Accounts Receivable outstanding.

A problem for the Superintendent of a district is to determine his budget and know that the income will exceed expenditures. Our budget for 1952 will be about $90,000, as follows:

$31,000	Maturing debt
10,000	Interest on debt
500	Treasurer's expense
500	Legal expense
2,000	Salaries of Commissioners and Clerk
500	Salaries of Town Assessors and Tax Collector
12,000	Water services
29,000	Operation and maintenance.

To cover these, I anticipate that we shall receive the following:

$36,000	from water rates
12,000	from service connections
36,000	from tax levy
6,000	transfer from surplus.

We expect to maintain a tax rate of $4.40 per thousand as in previous years.

At this time I should like to express my thanks to Whitman & Howard, Engineers, Mr. Paul Howard, Mr. C. R. Wickerson, and Mr. Roger Pearson, on whom I depended so much when I first took over the position of Superintendent in April, 1946. In the 1½ years that Mr. Wickerson was Resident Engineer, he took me in hand and taught me as many of the details as possible. My thanks for their help go to all who have had a part in the construction and development of the Dennis Water District, and to my many new friends in the New England Water Works Association for their ever-friendly help when problems and questions arise.

MEMBRANE FILTERS AND THEIR USE FOR THE BACTERIOLOGICAL ANALYSIS OF WATER

BY L. W. SLANETZ*

[*Read May 15, 1952.*]

Introduction

It is indeed a pleasure to take part in this meeting of the New England Water Works Association and discuss with you the use of membrane filters for the bacteriological analysis of water. As I indicated to Professor Brown when he first invited me to speak on this subject, we have not carried out any extensive research as yet in our laboratory on the use and efficiency of these filters for estimating the numbers and types of bacteria in water. However, we have some studies under way and have obtained some preliminary results. I have also been interested in reviewing the literature relating to these filters and have had the opportunity to hear papers by Dr. Kabler and Mr. Clark of the U. S. P. H. S. Environmental Health Center, Cincinnati, O., and Dr. Goetz of the California Institute of Technology, Pasadena, Cal., at the time of the American Public Health Association meeting last October in San Francisco. About two months ago I also had the privilege of visiting with Dr. Kabler and his associates at the Environmental Health Center in Cincinnati and discussing with them some of the work they are carrying on there. This group also presented a paper on the evaluation of differential media on the membrane filter at the recent Society of American Bacteriologists meetings in Boston, which I attended.

Development of Membrane Filters

While membrane filters were prepared about 60 years ago by Sanarelli (1) and others, methods for their production were greatly improved by Zsigmondy and Bachmann in 1916-1918 (2). As a result of the Zsigmondy studies, and after certain refinements were made, these filters were commercially produced by the Satorius-Werke Co., Goettingen, Germany. In 1922 Meyeringh (3) reported on the

*Professor of Bacteriology, University of New Hampshire, Durham, N. H.

use of the Zsigmondy-Bachmann membrane filters for the filtration of bacteria. Prior to and during World War II, techniques were developed in Germany and probably in Russia for the use of membrane filters for the rapid and economical detection and quantitative determination of *E. coli* and enteric pathogens in water supplies. During the period 1943-1950 a number of papers were published in German journals describing these techniques. Procedures were developed for the culturing of the bacteria directly on the filter membranes by means of selective or differential culture media. These procedures are apparently now being used on a considerable scale for the bacteriological examination of water in Germany.

Shortly after World War II, Dr. Alexander Goetz of the California Institute of Technology, under the auspices of the Joint Intelligence Objective Agency of the Armed Services, visited Germany to study the German development in the field of membrane filtration, particularly as it related to the bacteriological examination of water. He reported the results of his investigations in Fiat Final Report 1312 in 1947 (4). Because of the possible application of these methods for the detection of biological warfare agents, the Biological Department of the Chemical Corps of the U. S. Army entered into a research contract with the California Institute of Technology. Under this arrangement, Dr. Goetz and his colleagues have made important contributions to the development and use of membrane filters for the bacteriological examination of water. As you know, some of the results of their investigations have been published in the December issue of the Journal of the American Water Works Association (5). Research on membrane-filter technique has also been conducted at the Environmental Health Center in Cincinnati, as I have already noted, and some of this work has now been published in Public Health Reports in July, 1951 (6), and in the American Journal of Public Health in April, 1952 (7, 8).

Nature of Membrane Filters

The Membrane Filters, also called at times Molecular Filters or Ultra Filters, are thin membranes, possessing a very smooth surface and uniform pore size. They are produced from cellulose or cellulose esters. The filters act or retain microbes by a sieve or screen action.

The membranes apparently have no absorptive or adsorptive properties. The bacteria are retained essentially on the surface and can be washed off or they can be cultured directly on the surface of the membranes by placing the membranes on filter paper, impregnated with suitable culture media. The nutrient diffuses through the pores to the surface of the membrane. The pore size of the membranes used for bacteriological analysis of water averages 0.5 to 0.7 microns and the membranes are usually circular disks, 50 mm (2 in.) in diameter.

Two types of the membrane filters are now available on the market in this country. The German or Satorius type of membrane filter can be purchased from Carl Schleicher and Schuell Co., Keene, N. H. The Goetz type of filter is now being manufactured by the Lovell Chemical Co., Watertown, Mass., and is called Millipore Filter. This filter has a standard square-grid pattern imprinted on the top surface, to facilitate counting of colonies of bacteria.

Techniques and the Applications of Membrane Filters in Water Bacteriology

Special types of filter holders have been developed for use with the membrane filters. One type, used in Germany, is called the Coli 5 Apparatus and is supplied by Carl Schleicher and Schuell Co. Dr. Goetz developed a stainless-steel filter apparatus of somewhat similar design. In this Coli 5 filter apparatus, the lower part of the funnel has a horizontal support containing a disc of sintered glass, on which a filter-paper circle is placed and then the membrane filter. The top part of the filter is then placed on the membrane and locked tight with a locking-ring arrangement. The filter unit is inserted with a rubber stopper into a filter flask, connected to a vacuum pump. A Pyrex Filter-holder is now available from the Lovell Chemical Co.

The filter apparatus can be sterilized by steam sterilization (121° C. for 15 minutes). It has not been found necessary to sterilize the apparatus before each filtration; careful rinsing with sterile water is sufficient. The initial sterilization can also be effected by use of alcohol or by use of boiling water.

The membranes may be sterilized by use of steam sterilization or ultra-violet light, or by exposure to ethylene-oxide vapor for 2 hours.

It should be noted that, at the present time, the Satorius-type membrane must be boiled twice, each time for 20 minutes in distilled water, before use. We have found that such treatment is sufficient sterilization for detection of coliforms and the membranes can be used without further treatment.

After the desired amount of water is passed through the filter, the membrane is removed with sterile forceps and is placed on an absorbent filter-paper pad, saturated with a suitable culture medium. Care must be taken to prevent the trapping of air bubbles between the pad and filter membrane. The dish with the above pad and membrane is then inverted and incubated at 37° C. in an atmosphere saturated with water vapor.

For determination of total counts, either single, double- or triple-strength lactose broth appears to be more suitable than nutrient broth. Clark et al. (6) found double-strength Albimi M medium plus 0.5% lactose the medium of choice. About 2 ml of the medium are added to each filter pad. The colonies are counted after 18 hours' incubation at 37° C. Certain types of raw water, containing considerable amounts of materials in suspension may coat the membrane and cause difficulty in obtaining accurate total counts.

For the detection and estimation of the numbers of coliform bacteria, the membranes are first placed on an enrichment medium of lactose broth or lactose Albimi M medium for 2 hours. The membranes are then transferred to pads saturated with Endo broth medium and incubated for 14 hours at 37° C. Clark et al. (6) used a modified Endo broth medium, which they believed gave better results than the standard Endo medium. The coliforms produce colonies with a typical metallic sheen on the filter membranes and can easily be counted.

We have found that the coliform count by the membrane technique was generally higher than the M. P. N. value, obtained by the standard presumptive and confirmed tests. It should be possible to obtain more accurate counts by the filter procedure. Other advantages include a definite saving in time, labor, materials and equipment. Large samples of water can be tested and the membrane cultures may be kept for permanent records.

Mueller (9), in studying a typhoid fever epidemic, was able to isolate *Salmonella typhosa* directly from drinking water on membrane

filters, using a modified bismuth-sulfite medium. She was not able to isolate this organism from these samples by other techniques. The membrane filters offer considerable promise for the isolation of pathogenic bacteria from water.

Some of you might be interested in knowing that in Germany, membrane filters of selected porosities have been used also for the chemical analysis of water. The membrane will collect colloidal iron and other solid material in suspension. More accurate determinations are reported by these techniques.

It should be emphasized that much more research is necessary before the efficiency of membrane filters for the bacteriological analysis of water is established. Information is still needed on the most suitable techniques and media for use with these filters. The results obtained must be carefully correlated with those obtained by the Standard Method now in use. I understand a project is now being set up in at least 10 laboratories, with the collaboration of the U. S. P. H. S. (E.H.C.) and the Committee on Standard Methods of Water Analysis of the A. P. H. A., to obtain some of this information.

However, the membrane filters offer real promise for the improvement of our present methods for the bacteriological analysis of water. These new techniques may well replace procedures now in use and prove more effective and economical for safeguarding the sanitary quality of our water supplies.

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PROCEEDINGS

April 1952 Meeting
University of Rhode Island, Kingston, R. I.
Thursday, April 17, 1952

In the morning the members and their guests inspected the water-filtration plant of the city of Providence, and then proceeded to the Scituate Reservoir watershed, where the forestry operations, then in process, were fully explained. After that inspection, the group continued on to the University of Rhode Island, where they were conducted through the College of Engineering.

After luncheon at Lippitt Dining Hall, the President of the New England Water Works Association, Frederick O. A. Almquist, introduced the invited guests at the head table, including Carl R. Woodward, President of the University of Rhode Island, who cordially welcomed the group and spoke briefly on the history of the University.

A paper, "Description of the Providence Water Supply System", was read by John J. Collins, Chief Chemist, Water Supply Board, Providence, R. I. Following this paper, a sound film, in color, on the Providence Water Supply was shown.

A paper, "Forestry Operations on the Scituate Reservoir Watershed", was read by William F. Cowen, Forester, Water Supply Board, Providence, R. I.

A paper, "Ground-Water Studies in Rhode Island", was read by William B. Allen, Resident Geologist, Ground Water Branch, U. S. Geological Survey, Providence, R. I.

May 1952 Meeting
Dartmouth College, Hanover, N. H.
Thursday, May 15, 1952

During the morning, members and their guests inspected the filtration plant of the Lebanon Water Works and saw a demonstration of the new filters. After this inspection, the group proceeded to Dartmouth College for a tour of the Thayer School of Enginering.

During the luncheon at Hanover Inn, the President of the New England Water Works Association, Frederick O. A. Almquist, introduced the invited guests at the head table. These included William P. Kimball, Dean of the Thayer School of Engineering, who welcomed the group to Dartmouth.

A paper, "Membrane Filters and Their Use for the Bacteriological Analysis of Water", was read by Dr. Lawrence W. Slanetz, Professor of Bacteriology, University of New Hampshire, Durham, N. H.

A film entitled "Your Valley—Your Future" was shown, with introductory remarks by Rufus Nelson, Vice-President of the New England Power Co.

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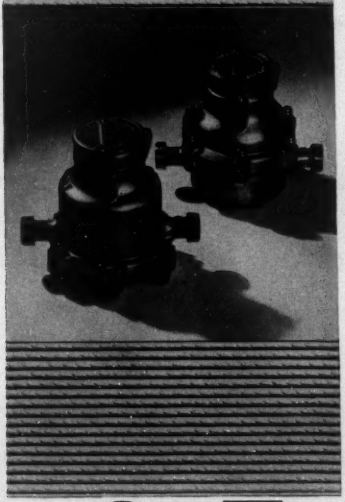

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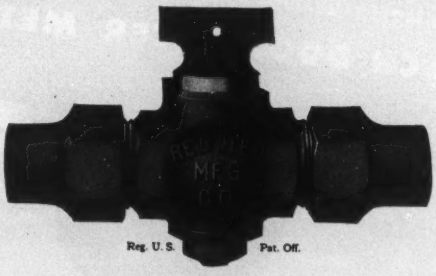

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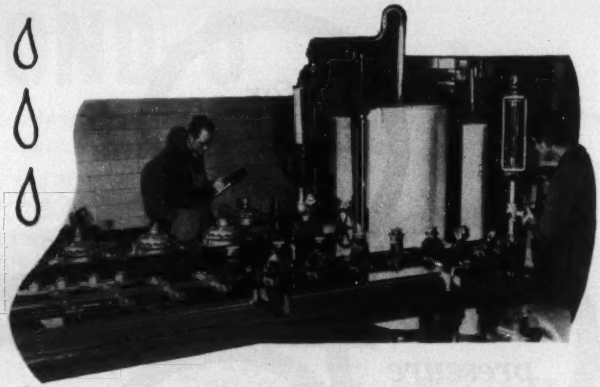

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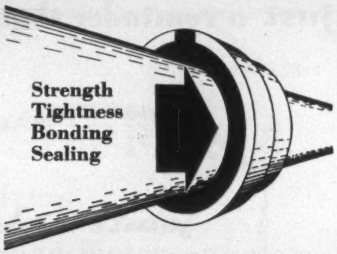

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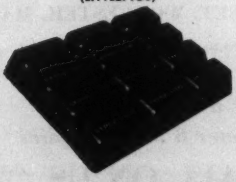
HYDRO-TITE (LITTLEPIGS)



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HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office 50 Church Street, New York General Offices and Works W. Medford Station, Boston, Mass.

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A Complete Line of Waterworks Supplies To All New England

Quality Products — Fast, Courteous and Dependable Service

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M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25F
On Request

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Pipe Line Equipment

New Hyde Park New York

Q.E.D.

Q.E.D.

No storage problem; no procurement problem; no materials handling.

Fully automatic. No complicated control problems.

Generated at point of use with equipment requiring little space.

No full-time supervision or labor required.

Constant, predictable operating cost.

"Q.E.D."

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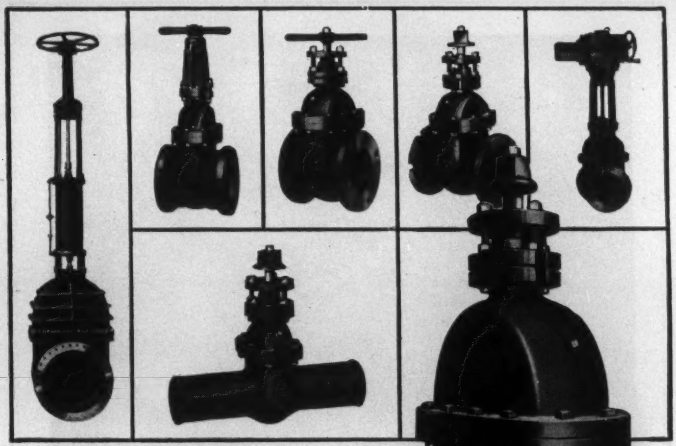
Pioneers in Continuing Ozone Research



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A.W.W.A. GATE VALVES

JOB-FITTED

...for a wide range of water works requirements

KENNEDY Fig. 56,
A.W.W.A. Standard
Double-Disc Gate Valve

Every KENNEDY A.W.W.A. valve job is JOB-FITTED . . . specially designed and engineered for the job it has to do. Conforming to A.W.W.A. standards in every detail, these KENNEDY valves offer many extra-value features . . . one being the iron itself, which is 50% stronger than ordinary cast-iron . . . to keep them on the job year in and year out.

KENNEDY manufactures a most complete line of water works valves . . . in sizes from 2" to 60" . . . non-rising stem and outside-screw-and-yoke types . . . with a wide variety of gearing arrangements, controls, accessories and end connections available.

WRITE FOR BULLETIN 106

THE **KENNEDY**
VALVE MFG. CO. • ELMIRA, N.Y.
Est. 1877

VALVES • PIPE FITTINGS • FIRE HYDRANTS

CITY OF CAMBRIDGE, MASS.

One of the latest DE LAVAL installations is pictured above as installed for the Cambridge Water Department.

The three units are all duplicates, designed for 8400 G.P.M. each against 175' T.D.H. at 1200 R.P.M. and are driven by 500 HP Synchronous Motors.

Specifications for this equipment were prepared by Camp, Dresser & McKee and the installation was made under their supervision.

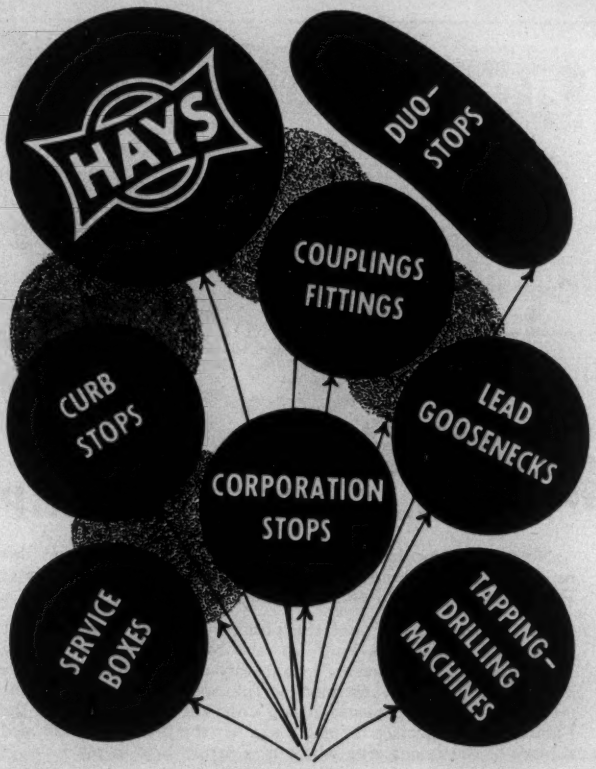
TURBINE EQUIPMENT COMPANY OF NEW ENGLAND

80 Federal Street **Phone LIberty 2-5993** **Boston 10, Mass.**

New England Representatives for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY



No need to buy corporation stops and saddles separately . . . the Hays "Duo-Stop" is a combination corporation stop and saddle . . . requires no tapping of main . . . installed without interruption of service . . . supplied with outlets for iron pipe or copper service, or various types of thread. It Pays to Buy HAYS . . . write for Folder 105 or ask the Man From Hays.

HAYS
COPPER · BRASS · LEAD · IRON
WATER WORKS PRODUCTS
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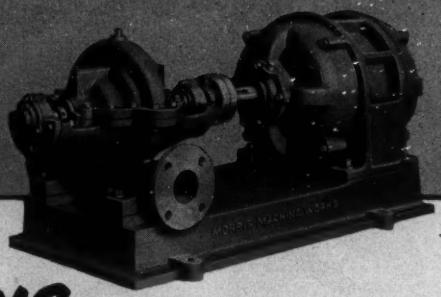
FLOATING Sealing Rings...

Permit CLOSER Running Clearances



MORRIS HORIZONTAL SPLIT Double-Suction WATER PUMP

No other pump has the Floating Sealing Rings . . . yet this exclusive feature alone makes the Morris Double-Suction Water Pump outstanding for efficiency and long service.

During the instant that the pump comes up to speed, but before full pressure is built up, the Morris Floating Sealing Rings adjust themselves to a uniformly close running clearance around the impeller. As soon as full speed is developed, the internal hydraulic pressure acting upon the vertical face of the Floating Ring, presses it tightly against the precision machined surface of the casing ring where it is firmly held in place.

This action permits machining the rings to closer clearances. Leakage is consequently reduced to a minimum, initial efficiency maintained for much longer periods of service. Assures concentricity of ring with impeller and eliminates binding due to abnormal operating conditions.

NEW ENGLAND REPRESENTATIVES
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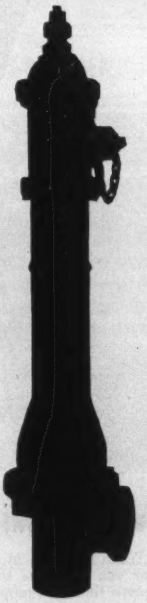
MORRIS Centrifugal Pumps

EDDY

Valves and Hydrants

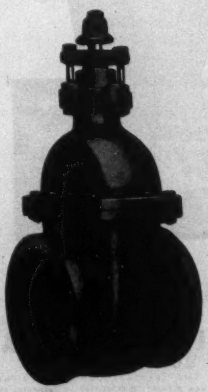


Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem — the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gate, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

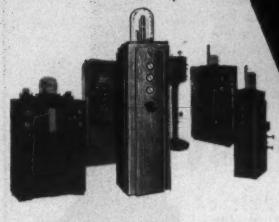


Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

WATERFORD NEW YORK

the part you don't see is important...



IN W&T CHLORINATORS, TOO!

When you look at a single W&T Chlorinator you can't see the basic research, the complete line of equipment, and the service that are behind it.

For instance, the engineer, the plant operator and the taxpayer all benefit from W&T's complete line of equipment. In the selection of equipment for a water supply — large or small — the engineer can always find a W&T Chlorinator to fit all requirements. The plant operator knows that this complete line can provide a W&T Chlorinator designed to help him provide safe water with his particular plant layout. The taxpayer is assured that money spent for W&T Equipment fitted to the present as well as the future needs of his community will provide long range economy.

These advantages of W&T's wide selection of equipment are probably one reason so many people use W&T Chlorinators.

WALLACE & TIERNAN COMPANY, INC.

CHLORINE AND CHEMICAL CONTROL EQUIPMENT

NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

S-70

BUILDERS

BUILDERS-PROVIDENCE

WATER and SEWAGE WORKS EQUIPMENT . . .

— for metering and controlling flow of liquids, air, dry materials. For Bulletins and complete information, address Builders-Providence, Inc. (Division of Builders Iron Foundry), Providence 1, Rhode Island.

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Warren Pipe Co. of Mass., Inc.

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CAST IRON PIPE

Flanged Pipe *Flexible Joint Pipe*
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Special Castings *Short Body B. & S. Specials*
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WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments

Get Full Service From Old Mains

The most practical way to meet today's overload demand is to clean clogged water mains. FLEXIBLE Underground Pipe Cleaning Co., specializes in such jobs— any size—2" to 72".

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New England Representative

Pipe Founders Sales Corporation

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Special Flanged and Bell and Spigot Castings

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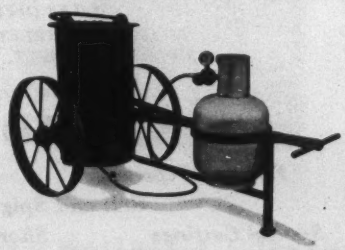
WATER SUPERINTENDENTS:

Consider the Advantages of Pollard L-P Gas Burner Furnaces

Burner, designed by Goss Engineers, burns L-P Gas (commonly known as "Bottled Gas"). Thoroughly tested and proven. Melts approximately 100 lbs. of lead or leadite in 10 minutes. Flame can be adjusted to maintain desired temperature. One cylinder of gas will operate units for many hours.

Cylinders are made of armor plate, equipped with relief valves.

Catalog No. 25 FA on Request



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PIPE LINE EQUIPMENT

NEW HYDE PARK **NEW YORK**

1879—ROSS— 1879

AUTOMATIC VALVES

Controls elevation of water in tanks, basins and reservoirs

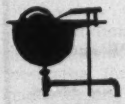
ALTITUDE VALVE

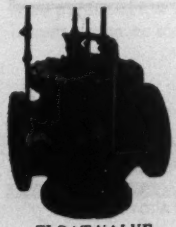
1. Single Acting
2. Double Acting

Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.





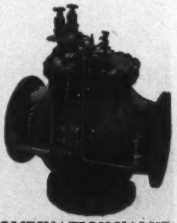
Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

FLOAT VALVE

A self contained unit, with controls three or more automatic



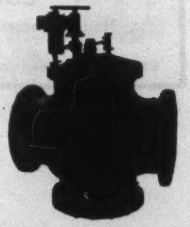
COMBINATION VALVE

Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge

SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

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Elevated Steel Tank at Waterbury, Conn.

The City of Waterbury, Conn., installed this Horton ellipsoidal-bottom elevated tank in its water distribution system to provide gravity water pressure. The tank has a capacity of 50,000-gals. and is 100-ft. to the bottom.

We build ellipsoidal elevated tanks of this design in standard capacities from 40,000 to 500,000-gals. Also, radial-cone bottom tanks with capacities from 500,000 to 3,000,000-gals.

We shall be glad to furnish information or quotations on Horton tanks.

CHICAGO BRIDGE & IRON COMPANY

201 Devonshire Street, Boston, Massachusetts

Eastern Plant — Greenville, Pa.

Attention Mr. Water Works Superintendent ! !

CEMENT LINED SERVICE PIPE:—

Resists Corrosion

Has proven practical for nearly three-quarters of a century

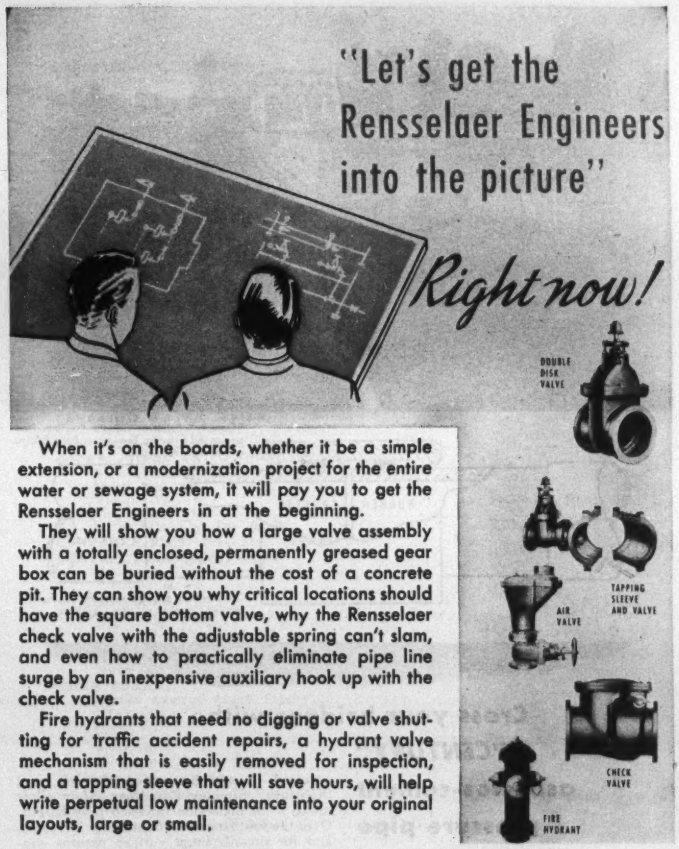
Immediate delivery can be made to waterworks on both wrought iron and steel, black or galvanized.

"SPECIFY EUREKA PIPE"

EUREKA PIPE COMPANY, Inc.

Manufacturers of CENTRIFUGAL CEMENT LINED PIPE and LEAD AND TIN LINED FITTINGS

591-593 WASHINGTON ST. TEL. 3-9550 LYNN, MASS.



When it's on the boards, whether it be a simple extension, or a modernization project for the entire water or sewage system, it will pay you to get the Rensselaer Engineers in at the beginning.

They will show you how a large valve assembly with a totally enclosed, permanently greased gear box can be buried without the cost of a concrete pit. They can show you why critical locations should have the square bottom valve, why the Rensselaer check valve with the adjustable spring can't slam, and even how to practically eliminate pipe line surge by an inexpensive auxiliary hook up with the check valve.

Fire hydrants that need no digging or valve shutting for traffic accident repairs, a hydrant valve mechanism that is easily removed for inspection, and a tapping sleeve that will save hours, will help write perpetual low maintenance into your original layouts, large or small.

Rensselaer VALVE COMPANY, TROY, N. Y.

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

A SUBSIDIARY OF NEPTUNE METER COMPANY

Sales representatives in principal cities

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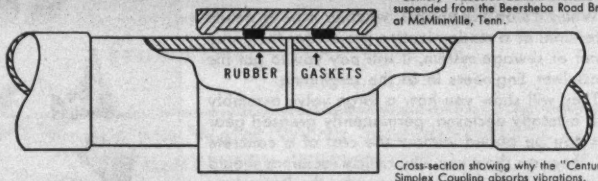
"Century" Asbestos-Cement Pressure Pipe suspended from the Beersheba Road Bridge at McMinnville, Tenn.



Cross-section showing why the "Century" Simplex Coupling absorbs vibrations.

Cross your bridges with . . . "CENTURY" asbestos-cement pressure pipe

Built for crossing bridges when it comes to them, "Century" Asbestos-Cement Pressure Pipe withstands vibration due to its inherently rugged construction and the rubber cushioning of its "Century" Simplex Couplings.

As you can see from the cross-section of the "Century" Simplex Coupling above, the pipe ends float in rubber gaskets which absorb these vibrations and the separation of pipe ends within the coupling localizes them to the individual pipe sections. Each coupling serves as an expansion joint.

Its light weight and handy lengths are easy to attach to bridge structures. Economies result because specially skilled labor is not required. It can be cut on the job, and "Century" Simplex Couplings safely allow up to 5° of deflection for each pipe length. Over the years its strength actually increases, and its smooth inner surface assures continuous maximum carrying capacity. The usual painting expense is completely eliminated. Here is high performance at low cost in water mains. Write for full data.

Write for Free Booklet, "Mains without Maintenance." Contains valuable reference material, specifications, and data for anyone interested in pipe for water mains.

Nature made Asbestos...
Keasbey & Mattison has made it serve mankind since 1873

KEASBEY & MATTISON
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